# Holocene sea level change and archaeology in the inner Thames estuary, London, UK.

Volume I: Text and figures
Volume II: Appendices



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## *Abstract*


# Holocene sea level change and archaeology in the inner Thames estuary, London, UK.

### Submitted in 2003 for the degree of Doctor of Philosophy

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This thesis examines the evidence for Holocene relative sea level change (RSL) in the inner Thames estuary. In addition, the nature of human occupation within the Thames floodplain is considered in the light of evidence for relative sea level and other environmental change. Furthermore, the use of archaeological data is tested as a means of obtaining useful and robust RSL datasets.

The Thames estuary, although one of the largest estuaries in the country, has not been examined since the late 1970's (Devoy 1977a, 1979) and subsequent examination of this work has suggested problems with the model. Nevertheless, the model is in common use, particularly by archaeologists to contextualize their findings. This thesis examines the problems with the sequence based on the typesite of Tilbury (Devoy 1979) and the unrepresentative nature of the model propounded on that site. A more simple but representative tripartite model is proposed for the study area from the City of London downstream to the border with Kent and Essex. This model indicates the presence of an initial Early Holocene marine transgression followed by a slowing in the rate of relative sea level rise and concurrent expansion of peat forming communities (wood peat and then alder carr) from *c.* 4800-3800 cal BC. This is followed by a second marine transgression starting *c.* 1500 cal BC and still in progress today.

Examination of archaeological evidence indicates a significant drop in river levels during the Roman period, for which there is no conventional sea level data available in the Thames. Subsequent periods show a rise in river levels and have also been used to reconstruct past tide levels. This indicates an almost tripling of the tidal range in central London since the Roman period. These data have been used to calculate sea level index points and show a discrepancy of almost 5m between those calculated with modern and Roman tide levels.

A key aspect of this thesis is to establish whether there was any response by the human population to changes in floodplain configuration. Examination of archaeological evidence indicates that there are links between environmental change and spatial patterning of human activity that can be distinguished from purely cultural processes. This is primarily associated with the initial transgression restricting land availability, followed by expansion of wetlands, creating more land for uses such as grazing stock. The second transgression sees a widespread abandonment of the floodplain, but not the hinterland. During this transgression, there is an apparent relatively short-lived drop in river levels, to which the Roman population adapts by constant rebuilding of the waterfront in an attempt to maintain a functioning port.

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## Declaration

The material contained within this thesis has not been used as submission for any other degree whatsoever.

## Statement of Copyright

## Acknowledgements

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# List of abbreviations

(*This does not include the Troels-Smith (1955) codes, which are given in Chapter 3.*)

| Abbreviation | Extension |
|---|---|
| AD | *Anno Domini* (In the year of our Lord) |
| ALT | Altitude |
| AMS | Accelerator Mass Spectrometry |
| BC | Before Christ |
| BGS | British Geological Survey |
| BH | Borehole |
| BP | Before Present (AD 1950) |
| C | Centigrade |
| C. | *Circa* (approximately) |
| CF | *Confer* (compares with) |
| CAL | Calibrated |
| CL | Centilitres |
| CTRL | Channel Tunnel Rail Link |
| DoE | Department of the Environment |
| ECRC | Environmental Change Research Centre |
| EH | English Heritage |
| EN | Engineering Pit |
| GLSMR | Greater London Sites and Monuments Record |
| GPS | Global Positioning System |
| GSF | Geoarchaeology Service Facility |
| HAT | Highest Astronomical Tide |
| HMSO | Her Majesties Stationery Office |
| ID | Indicative Difference |
| IGCP | International Geoscience Programme |
| IM | Indicative Meaning |
| LAT | Lowest Astronomical Tide |
| LOIS | Land Ocean Interaction Study |
| MAP2 | The Management of Archaeological Projects (2nd edition) |
| MHW | Mean High Water |
| MHWNT | Mean High Water of Neap Tides |
| MHWST | Mean High Water of Spring Tides |

| | |
|---|---|
| MLWNT | Mean Low Water of Neap Tides |
| MLWST | Mean Low Water of Spring Tides |
| MM | Millimetres |
| MoD | Ministry of Defence |
| MoLAS | Museum of London Archaeology Service |
| MSL | Mean Sea Level |
| MTL | Mean Tide Level |
| NGR | National Grid Reference |
| OD | Ordnance Datum |
| OS | Ordnance Survey |
| OIS | Oxygen Isotope Stage |
| PAZ | Pollen Assemblage Zone |
| PLA | Port of London Authority |
| PPG16 | Planning Policy Guidance Note 16 |
| RRL | Relative River Level |
| RSL | Relative Sea Level |
| RSPB | Royal Society for the Protection of Birds |
| RWL | Reference Water Level |
| SLIP | Sea Level Index Point |
| SSSI | Site of Special Scientific Interest |
| TOC | Total Organic Carbon |
| TST | Total Station Theodolite |
| U4/100 | Borehole core sample, (4 inches/100 millimetres) |
| UCL | University College London |
| UDP | Unitary Development Plan |
| VAR. | Variety |
| VCH | Victoria County History |
| VOL. | Volume |
| $^{14}C$ | Radiocarbon |
| ° | Degrees |
| $\chi^{lf}$ | Low Frequency Magnetic Susceptibility |

# Section I: Introduction

## *Chapter 1. Introduction to the thesis*

### 1.1 Introduction

This chapter outlines the concepts behind this thesis. The aims and objectives are stated, followed by reasons, questions and indeed whom the work might ultimately benefit. The spatial and temporal boundaries of the study are defined and the structure of the volumes outlined. As this thesis has been undertaken from within a slightly unconventional background within a department of Geography, a brief discussion of developer-funded archaeology has been included.

The Thames has been studied for several hundred years, but erratically rather than systematically. Some aspects of its history are reasonably well known, such as the Pleistocene terrace sequence (Bridgland 1994; Gibbard 1994), whilst the Holocene sequence is only now beginning to be more widely understood (Devoy 1979; Bates and Barham 1995; Wilkinson et al. 2000). This follows a hiatus of approximately a century since the work of Blandford (1854), Spurrell (1885, 1889) and Whittaker (1889) and others unraveling the sedimentary history of the river. Much of this work was undertaken opportunistically, following exposures cut for construction work, such as dock excavation, in much the same way records are made today. In addition to the lithological descriptions and section drawings, the ecology and archaeology of the floodplain was also studied. This thesis was undertaken to more fully develop an understanding of the interaction between the human communities and their environment in the Thames from the Early Holocene to the medieval period.

*'The history and antiquities of all nations and societies have been objects of inquiry to curious persons in all ages, either to separate falsehood from truth and tradition from evidence, to establish what had probability for its basis, or to explode what reflected only on the vanity of the inventors and propagators'*

(Anon, 1770, introduction to *Archaeologia* vol. I)

## 1.2 Aims

The aims of this study are:

1. To establish the record of relative sea level (RSL) driven riverine and estuarine changes in the inner Thames estuary during the Holocene

   *This issue is central to the thesis; most previous studies of RSL in the Thames relate solely to the middle and lower Thames, including the now classic work of Devoy (1979). This needs mapping and comparing with the inner estuary to better understand estuary wide trends and human response and to provide a long-term backdrop for examining prevailing rates of sea level change; a subject of increasing importance for those responsible for river defence and flood management.*

2. To examine developing patterns of archaeological settlement in proximity to the Thames

   *The Thames floodplain has been widely used in the Holocene, as a routeway, resource base and home. This aim specifically relates to the examination of whether sea level change would have influenced the lives of the human populations that used the floodplain and whether any response to environmental change arising from changing river dynamics can be tracked in the archaeological record.*

3. To explore the links between data gathered during study of RSL change and archaeology in the Thames floodplain

   *Archaeologists have been interested in river level changes in the Thames for several decades and have evolved their own methodologies for studying such change. This aim is directed towards establishing what benefits may be accrued by a fusion of the methods used and results obtained within the disciplines of earth science and archaeology.*

## 1.3 Objectives

1. To revise the current sea level curves for the Thames (Devoy 1979; Long 1995; Sidell et al. 2000, 110).

2. To establish a pattern of Holocene sedimentation in the middle Thames estuary.

3. To evaluate the geographical and archaeological methodologies used in the construction of sea level index points.

4. To evaluate the use of palaeotidal data in the calculation of relative sea level.

5. To examine anthropogenic influence on tidal range in the Thames.

6. To examine methods of reconstructing sea level changes in the historic period.

7. To examine the links between spatial patterning and chronological distribution of archaeological sites within the Thames floodplain.

8. To examine the validity of undertaking doctoral research using material collected within the context of developer-funded archaeology.

## 1.4 Research framework

A decision was made to undertake this thesis when it became clear that archaeologists in central London needed a new model of sea level change and sedimentation to provide a context in which to interpret the results uncovered daily on archaeological sites. The 'Tilbury' model proposed by Robert Devoy in 1979 (henceforth referred to as the 'Devoy model') was being applied to practically any site with peat on it, irrespective of where the site was, geographically, altitudinally and chronologically. His study area stretches from the Isle of Grain to Crossness, with sequences dating from the Mesolithic through to the Roman period. Furthermore, the Holocene Thames did not seem to be a focus of research within the earth science community, unlike many other British rivers, such as the Severn (Allen 1987, 1990; Allen and Rae 1988; Scaife and Long 1994; Bell 2000). Working in such an environment was immensely frustrating, and this, in combination with a strong desire 'to know', led to the proposal to undertake this thesis.

To examine the sedimentary history, evidence for sea level change and the validity of using the Devoy model in the inner estuary, it was necessary to collect data from the area and periods in which most archaeology was undertaken, i.e. Holocene deposits in central and east London. For reasons that seemed perfectly sensible at the time, it was decided to accumulate samples whilst continuing to work as a professional environmental archaeologist for a commercial unit employed within the sphere of developer-funded archaeology.

In order to make use of as full a dataset as possible, information from a range of other sites in the study area previously examined through the archaeological process is also drawn upon. A key driving force behind all archaeological research is to work towards ever-increasing resolution. When analyzing and interpreting cultural change, archaeologists wish to be able to do this at a level meaningful within human timescales, ideally generational, in order to more fully understand how, for instance, environmental change affected the lives of individual people. This requires extensive datasets simply because archaeological assemblages are many times reduced from the actual life assemblages (Orton 2000, Chapter 3) and extrapolating back into the past is consistently fraught with problems associated with complex taphonomic issues. Therefore, although this research is in large part driven by earth science methods, a large dataset was considered important in order to achieve information meaningful within an archaeological context.

## Geography and Chronology

The geographic area best able to address the aims and objectives stated above needed to cover significant areas of archaeology and also to overlap with the Devoy study area. To this end, the City of London is included with sites stretching downstream to the border with modern Essex, thus including the western zone of Devoy's study area.

Chronologically, this study is solely concerned with the Holocene, although reference is occasionally made to Pleistocene gravels. The chronologies constructed for this thesis have been undertaken almost entirely using the radiocarbon method. Dendrochronology is always preferable owing to the higher resolution that can be achieved, but it was rarely possible owing to problems of obtaining absolute dates on prehistoric timbers in the London region. As this research takes place at the boundary between archaeology and physical geography, it was chosen to quote the radiocarbon measurements in both calibrated years Before Christ (BC) and radiocarbon and calendar years Before Present (BP) (AD 1950). Although this may occasionally appear clumsy it is intended to make the data accessible to a greater range of people. Conventional archaeological nomenclature of chronological/cultural periods is also used, i.e. Mesolithic, Bronze Age and Roman. Although there is some debate about the application of cultural terminology to chronological periods (see Cotton 2000 and Bradley 2001), they are used here for convenience. A chronological table is given below (Table 1) for clarity about how the period divisions relate to the radiocarbon and calendar years.

| OI STAGE | EPOCH | STAGE | CULTURAL PERIODS | CALENDAR YEARS BC/AD | CALENDAR YEARS BP | $^{14}C$ YEARS BP |
| --- | --- | --- | --- | --- | --- | --- |
| One | Holocene | Flandrian | Post-medieval | | | |
| | | | medieval | | | |
| | | | Saxon & Danish | AD 1000 | 1000 | 1000 |
| | | | Roman | | | |
| | | | Iron Age | 0 | 2000 | 2000 |
| | | | Bronze Age | 1000 BC | 3000 | 3000 |
| | | | | 2000 | 4000 | 4000 |
| | | | Neolithic | 3000 | 5000 | |
| | | | | 4000 | 6000 | 5000 |
| | | | Mesolithic | 5000 | 7000 | 6000 |
| | | | | 6000 | 8000 | 7000 |
| | | | | 7000 | 9000 | 8000 |
| | | | | 8000 | 10,000 | 9000 |
| | | | | 9000 | 11,000 | 10,000 |
| Two | Pleistocene | Devensian | Upper Palaeolithic | 10,000 | 12,000 | |
| | | | | 11,000 | 13,000 | 11,000 |
| | | | | 12,000 | 14,000 | 12,000 |

Table 1. Chronological chart

## 1.5 Structure

### Volume I: Text

The text is divided into four sections, each outlining a key aspect of the thesis. These are further subdivided into chapters, each focusing on a particular part of the discussion. Section I provides the rationale behind the study, along with basic information regarding selection of sites, techniques and developer funded archaeology. This is followed by a brief outline of sea level research and archaeology in London and the Thames estuary. Section II contains the narrative for each of the sites selected to provide core data to examine the aims and objectives articulated above. Within each chapter, the location, previous information on the area and reasons for inclusion are articulated, followed by a summary discussion of the litho- and biostratigraphic sequences for each site. Section III presents the analysis and synthesis, looking at sea level change, sedimentation and patterns of archaeological activity. Section IV draws together the conclusions of the study in conjunction with an evaluation of how well the original aims and objectives have been answered. It highlights the new questions that have arisen during the project and outlines future issues requiring research and resolution. Volume I concludes with a list of references cited.

### Volume II: Appendices

The use of appendices has been designed to allow a more free-flowing interpretative text. All raw data for the main sites described in Section II, in conjunction with some basic descriptive text, is contained within the appendices. This includes sedimentary and biostratigraphical grouping within the individual sites. Diagrams and tables supporting the raw data are also to be found in the appendices. A final appendix includes the data used for the RSL calculations.

# 1.6 Developer funded archaeology

## Introduction

Developer funded archaeology is the term given to archaeology undertaken within a commercial sphere, generally in advance of construction and funded by the property developer or land owner (see Figure 1). This form of archaeology is carried out by professional units and is regulated in England by local authority planning officers advised by archaeological curators, generally county archaeologists and English Heritage officers. There is an artificial divide between developer funded and 'research' archaeology; the latter generally undertaken by university departments with the inherent (but often misguided) understanding that research archaeology is of a higher quality. In fact, only highly professional archaeologists are able to function to the stringent requirements of financially astute developers and rigorous curators. This thesis is based on research undertaken within the context of developer-funded archaeology.

## The discipline in London

Professional archaeologists took over from the amateurs in the middle of the twentieth century, after the Second World War. Professor W.F. Grimes pioneered what was initially termed 'rescue' archaeology by taking the opportunity to investigate many bomb-damaged sites in the City of London, prior to their redevelopment (Grimes 1968; Shepherd 1998). Subsequently, archaeologists working for firstly the Guildhall and then the London Museum undertook excavations, mainly in the historic city, but also in other locations prior to redevelopment. Professional units were established in the early 1970's to undertake all the work that could be identified (and paid for), but this tended to involve a reactive approach to discoveries and much archaeology was lost at this time. Furthermore, although securing funds for excavation was not impossible, finding money for publication was significantly harder. It was not until 1990 that improvements were made by the introduction of government guidance, Planning Policy Guidance note 16 (PPG16, Department of the Environment 1990).

Figure 1. Developer-funded excavation underneath Borough High Street, from Drummond-Murray et al. (1998)

### Planning Policy Guidance Note 16

PPG16 is one of a series of government advisory notes governing planning, in this case, archaeology and planning. It is used to regulate building and development in archaeologically sensitive areas of the country and is implemented by country archaeologists and curators to advise planning and development control officers to assign appropriate 'conditions' to planning permission consents. An archaeological condition regulates how the site is developed and will make provision for evaluation, excavation or watching brief, to be paid for by the developer of the site, using 'the polluter pays' principle. In this way, the archaeological heritage of an area can be preserved 'by record', i.e. the archaeology is removed but a record of what was found is maintained in an open access archive. A further method of protection comes with a key thrust of PPG16; the preservation of archaeological remains *in situ*. This states that where nationally significant remains are discovered, there should be a presumption in favour of preservation *in situ* wherever possible. This is in order to secure some of the finite archaeological resource for archaeologists in the future who will have more refined and advanced techniques.

The use of PPG16 has opened up developer-funded archaeology significantly since it was published. Before this, the selection of sites for excavation tended to be based on prior knowledge of the areas significance and did not invest heavily in evaluation of sites in archaeologically unknown areas. This has now occurred with the consequence that many new areas of the country have been investigated and proven to have a rich archaeological heritage. One particular area that has benefited is the relatively deprived area of northeast London, heavily featured within this thesis, the archaeology of which was largely unknown before 1990.

Nevertheless, there are still significant problems with the system. As stated above, within this process the developer pays for the archaeological project. However, the project will be firmly restricted to the footprint of the development and no more, i.e. if a new basement will penetrate 1.5m below ground surface, archaeology will only be recorded and removed to this depth even if archaeological horizons are present below this level. Archaeological stratigraphy in some parts of London can reach thicknesses in excess of nine metres. The restriction to only excavate within the immediate area of impact is in the spirit of maintaining as much archaeology *in situ* as possible. A further problem comes with palaeoecology; although the palaeotopographic and ecological context of an area is crucial to the understanding of human development, within PPG16, purely environmental analyses can only be justified with difficulty.

The next major problem comes with suitable provision for publication. The developer is obliged to pay for publication of their particular site if it merits it, but no more. This leaves significant amounts of information in the 'grey literature' of desktop assessment, evaluation and assessment reports that do not see the light of day. Naturally, the question of what does and does not merit publication is a highly contentious area. However, the key issue is that developers are only required to publish 'their' site. This means that sites next to each other can rarely be integrated and published in a meaningful manner. Moreover, it means that within developer-funded archaeology there is no provision for synthetic work. This reduces archaeological endeavour to little more than a conveyor system churning out reports of some value, but with scant ability to move research on. In a very few cases, an enlightened developer will pay for additional work, for instance, London Underground Limited funded a geomorphological project during the extension of the Jubilee Line (Sidell et al. 2000), but on the whole, synthesis cannot occur and relies upon 'academic' and 'amateur' researchers who generally have little time and less funding.

This thesis has been undertaken within this context. Since the early 1970s, archaeologists in London have been interested in the Thames and how its development has related to human occupation and settlement in the area. Work was undertaken on individual sites (discussed below), but very little attempt at synthesis was made. Following the publication of the Devoy model (see below) in 1979, archaeologists gradually began to use aspects of it, and descriptions of stratigraphy encountered on sites would contain references to 'Tilbury IV' for instance. Devoys paper has been cited as one of the three most important papers relating to archaeology in London published in 1979 (Cowie and Densem 2000). Nevertheless, the model has been criticized periodically since it was published (Shennan 1987; Haggart 1995; Long 1995) and the (mis-) application of it to archaeological sites has also been noted (Rackham 1994). Nevertheless, it is only recently that a new model has been suggested (Long et al. 2000), but this is a simple one, examining regional rather than local trends. Nevertheless, it is crucial for archaeologists working in the Thames estuary to have a detailed understanding of the river dynamics in order to fully understand how the human societies have developed within their landscape.

Therefore, this project uses data collected from the Thames *via* developer funded archaeology to attempt to test the models of sea level change currently available and, if the data support it, to propose a more detailed model than those of Devoy (1979) and Long et al. (2000). Furthermore, it attempts to highlight that there need be no division between the 'academic' and the 'professional' archaeologist, and that truly synthetic research can arise through the developer-funded process and hopefully be of benefit to the wider archaeological and earth science communities.

# Chapter 2. Literature review

## 2.1 The history of sea level research

Relative sea level change has been studied since at least the 1st century cal BC in Europe, and even before in China. Devoy reviewed the subject (Devoy 1987, 1-2), indicating that a true scientific approach started with Leonardo da Vinci in the fifteenth century but really first centred on Scandinavia. Researchers included Celsius, Linnaeus and Runeberg, postulating theories such as humus production leading to decreasing ocean levels, creationist theory and crustal shift. Devoy (1987, 3) identified Maclaren as one of the key figures in the history of sea level analysis (Maclaren 1842) with his discussion of land/water interaction relating to ice sheet growth/decay, followed by Jamieson (1865) who identified the concept of uplift as glacial rebound. From then on, research was mainly concerned with ice loading and crustal movement, rather than glacial discharge. It was sometime later that Daly (1934) redressed the balance, synthesizing the fundamental concepts of land, ocean and ice-sheet interaction.

The emphasis subsequent to this period of endeavour focused on the correlation of individual strands of research, either regionally, or increasingly at a global level. Devoy (1987, 5) cites Godwin (1943) as an early exponent with his work identifying the significance of inter-regional comparison and emphasizing palynology as a means to assist comparison and strengthen correlation of chronology (before radiocarbon dating). The quest for global correlation at this time is described by Devoy (1987, 6) as a kind of Holy Grail and would appear to have been the driving question in sea level studies in the 1950's. The research led to several schools of thought (Jelgersma 1961):

- *Rapid rise to above current levels with an oscillating trend (Pacific and Australasian school)*
- *Current sea level achieved by 3600 BP and subsequently stable (American school)*
- *Current sea level achieved only very recently after gradual but constant rise (European school)*

This debate on the very nature of RSL change then ushered in what could be termed the modern era of study, including the inception of the International Global Correlation Programme (IGCP) sea level projects (now known as the International Geoscience Programme) and the subsequent diversification of research focus. It was realized that many factors control sea level change and that a single curve cannot accurately incorporate all these influences. This led a move away from the attempt to create a global curve, the problems with which have been widely discussed (see Morner 1976; Tooley 1985; Shennan 1987) and termed a '*fruitless quest*' (Long and Roberts 1997). A re-evaluation of priorities turned research towards a more intense focus on smaller scale change.

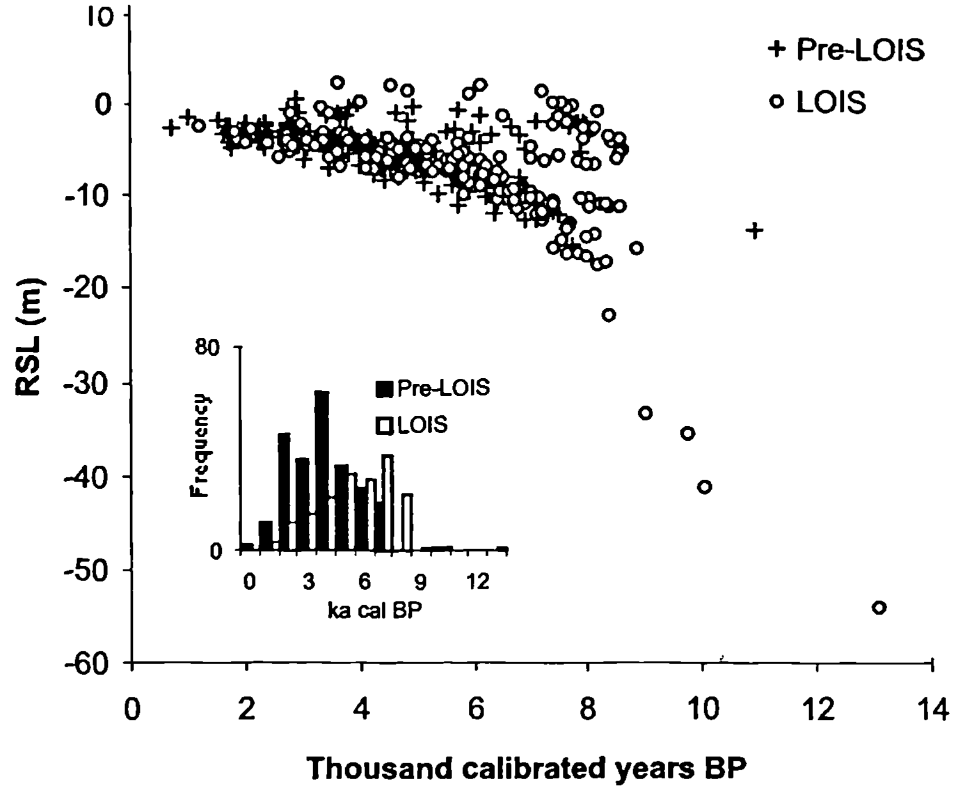
## 2.2 Methods for establishing sea level change

### Age/altitude graphs

Throughout the history of sea level studies, RSL curves have been ubiquitous, traditionally using observed points where age and altitude have been identified and confirmed (see Figure 2). They have varied, from graphs based on one site, through regional graphs to attempts at a global sea level curve. The graph below shows the trend of Holocene sea level rise on the English east coast.

One of the major issues was the methodology used to construct individual curves. Tooley (1978a) stated the criteria required to construct a valid regional curve:

- *Data should come from a small homogeneous area to minimize factors that could introduce error*
- *Index points should be based on material from similar palaeoenvironments*
- *Radiocarbon data should be capable of independent corroboration (i.e. by pollen analysis and chrono-zonation)*




LOIS = Land-Ocean Interaction Study

Figure 2. Regional age-altitude graph, from Shennan et al. (2000)

Tooley advocated use of these criteria to assess the validity of data used in the construction of extant sea level curves. This was an important point and one that could be used to satisfy the needs of data verification for previously published curves. Subsequently, Tooley (1982) addressed the terminology associated with the construction of age/altitude graphs with specific reference to the misapplication of *regression* and *transgression* overlap. The trend of associating process with facies types was also discussed and he concluded that the terms regressive and transgressive overlaps should be associated with the retreat and advance of the sea, but not specific controlling processes such as a fall or rise in sea level. Unfortunately, even with other papers addressing the problems of misapplied terminology (Shennan 1986), this continues to be a problem.

### Index Points

Much of the discussion relating to methods of constructing curves has centred on the construction of individual index points, which are the building blocks of RSL analysis. Tooley (1979) defined sea level index points as a

*'radiocarbon date on biogenic material either immediately below or immediately above a marine transgression.'*

Although this does not stress the need for altitudinal control or the need for the biogenic material itself to reflect marine influence, it at least emphasizes the need for tight chronological control at a change in facies type. Subsequently, Devoy (1982) identified three selection criteria:

- *Direct access of the sea to each site at the time when the dated level used to indicate a sea level position was being formed.*
- *Availability of palaeoenvironmental indicators such as pollen, diatoms, foraminifera and mollusc shell evidence to show the presence of marine or brackish water conditions at the dated level.*
- *Determination of the indicators relationship to a specific palaeotidal level.*

This redressed the need for direct marine influence to be felt at the sampling location (although 'direct' was never defined) and also brought in the issue of specific tide levels. It was Shennan (1982) who emphasized the problem of palaeotide levels, expanding on the term 'indicative meaning' (IM), previously used by van de Plassche (1986, 9) and defined as the relationship of the local environment (in which it accumulated) to a contemporaneous reference tide level.

Shennan (1982) highlighted this as being fundamental to establishing individual index points. It was seen as necessary for valid comparison between the differing samples used to construct index points and was generally given as a measurement. Four points were stressed:

- *IM is dependent on the type of stratigraphic overlap.*
- *Reference water levels for different sample types should not be related to the same tide level (e.g. mean high water of spring tides (MHWST), mean tide level (MTL)) by using individual constant factors, (e.g. mean high tide (MHT) +180mm for* Phragmites *peat, MHT+0.4m for fen wood) but should be expressed as a function of the tidal curve.*
- *Indicative range can be reduced by dating the level at which pollen, diatom, macrofossil and stratigraphic evidence reveal a change in the depositional environment.*
- *The accuracy of the reference tide levels must be assessed.*

These suggestions assisted in constructing index points and consequently sea level curves. Tooley (1982) advocated the presentation of flagged index points, divided into those from transgressive and regressive overlaps on age/altitude graphs, something that may be seen in the work of Devoy (1979). Nevertheless, (as became apparent with Devoys model) it is possible that what may initially appear to be a regressive overlap may prove to have formed under rising sea level, therefore the publication of marked points may do more harm than good.

Shennan revisited index points in the publication of *The Fenland Project (9)* (Shennan 1994; Waller 1994a, 53) where he coded them according to location within sedimentary facies (see Table 2). These have varying levels of usefulness as index points, but are not ranked strictly numerically. Shennan advocated that age/altitude graphs should be plotted using only index points of one code. Although this advanced the ability to assess data quality, there are some practical difficulties, i.e. if a graph relies on data from one site only, there may only be one base of basal peat point. Nevertheless, at a regional scale there are many benefits in using this method of data classification, which lends rigour to the results and presentation and may also be used to address issues of sediment compaction. It is also closely tied to a system of indicative range calculation and construction of the reference water levels required to produce index points (Shennan 1994). However, the system has not been widely used outside the University of Durham.

| Code | Description |
|---|---|
| 1 | Good positive tendency of sea level movement. From a transgressive contact, or a stratigraphic change indicating a positive sea level tendency. No indication of erosion. |
| 2 | Poor positive tendency of sea level movement. From an apparent transgressive contact but where either erosion is suspected or possible, or there is no supporting biostratigraphic evidence from the site. |
| 3 | Base of basal peat dated. |
| 4 | Sample from within basal peat, but not from the base, or from the transgressive contact (i.e. not 1, 2 or 3). |
| 5 | Good negative tendency of sea level movement, from a regressive contact, or a stratigraphic or biostratigraphic change indicating a negative sea level tendency. There is no indication of a hiatus in sedimentation. |
| 6 | Poor negative tendency of sea level movement. From an apparent regressive contact but where either a hiatus is suspected or there is no supporting biostratigraphic evidence from the site. |
| 7 | Sample from any part of a sequence beyond the limit of marine sedimentation. |
| 8 | Sample from an intercalated peat where no single tendency can be defined. It represents a minimum age for a negative tendency followed by a positive tendency. |
| 9 | Sample cannot be reliably related to a specific sea level tendency in terms of age, altitude or indicative meaning. |

Table 2. Codes and descriptions for tendency types, from Shennan (1994)

Long and Tooley (1995) subsequently re-examined the criteria for defining index points. They identify the five principal attributes required:

- *Location*
- *Age*
- *Altitude*
- *Indicative meaning*
- *Reference tide level*

It could be argued that the reference tide level is simply an aspect of establishing IM and need not be separated. They further defined IM for regressive and transgressive events as *c.* 200mm (after Shennan 1982, 1986). However, there are inconsistencies as Shennan also recommended a cumulative error of ± 300mm. Long and Tooley also make the assumption that overlaps form at MHWST but stress the importance of reducing this to Mean Sea Level (MSL) in order to avoid the problems of spatial variation in MHWST. Nevertheless, this is based on the assumption of constancy in tidal range and therefore subject to problems. Furthermore, the overall effects of long-term sediment compaction (discussed below) are of much greater significance than the relatively minor calculations and errors invoked when constructing reference water levels (A.J.Long, pers comm.). This approach has perhaps introduced an element of complacency into error estimation - many graphs still include spreads of up to 4m; significantly more than predicted by the error calculations.

## Tendency

A development from the sole use of age-altitude graphs came with the development of 'tendency' graphs (Morrison 1976, and see Figure 3). Tendency is taken as representing an increase or decrease in marine influence at that location (Shennan 1982; Long 1992) and has been used to identify local and also regional trends in RSL change. This dual approach of using age/altitude graphs in association with analysis of the trend of marine influence has been examined by Shennan (1980, 1986, 1987) and Long (1991, 1992). Tendency was also discussed by Plater and Shennan (1992), who stressed the importance of local factors (i.e. coastal morphology and local sedimentation rates) in attempting to model sea level change whilst identifying the possibility of identifying local and regional trends by isolating the dominant tendency at given locations. Tendency analysis relies upon clearly defined regressive and transgressive contacts, which are the focal point for data collection. It is a simple and underused mechanism for examining local trends in sea level movement. More recently, it has been undertaken in the Humber (Kirby 1999) and at Goldcliff in the Severn estuary (Bell 2000, 327).

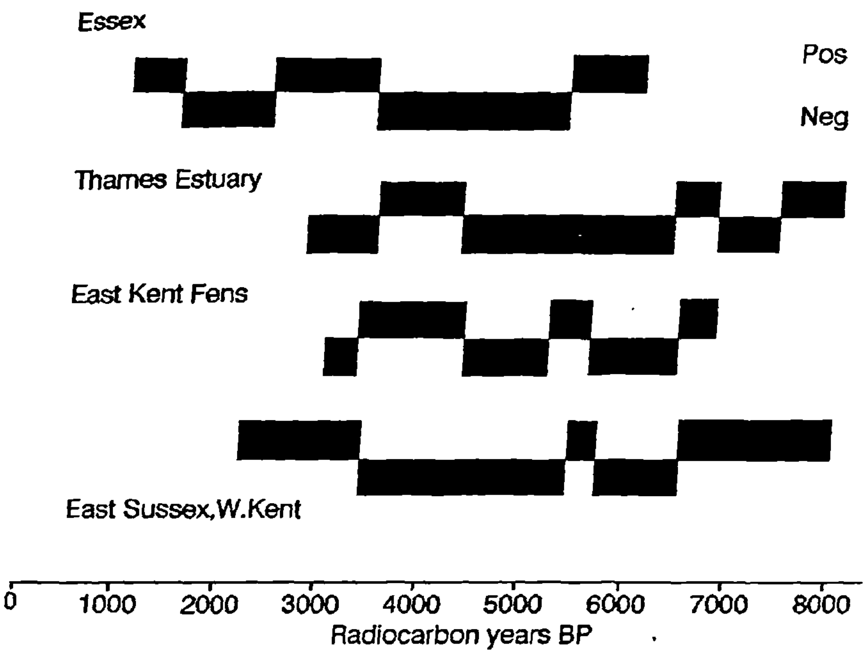



Figure 3. Tendency graph, from Long (1991)

### Error

The calculation of sea level index points, and thereby RSL change, is subject to a number of difficulties and errors that can obscure the 'real' picture. This has often been mentioned, but generally only as a very brief introduction to wider discussions of data or synthetic research. Shennan (1986a) developed previous discussions (Shennan 1982) of the use of age/altitude graphs, but rejected their use as too simplistic an approach, suggesting that analysis should be taken to the stage of offering a three-dimensional process model; a method that has not, perhaps unsurprisingly, been widely adopted. Criteria to avoid 'misleadingly precise' curves were indicated with five major problems isolated:

- *The ability to adequately record altitude.*
- *Estimation of the original altitude of contacts.*
- *Establishing the indicative meaning.*
- *Adequately dating the sample.*
- *Equating lithological change with sea level change.*

This last point is one that had also been emphasized by Tooley (1982), who criticized the practice of directly associating process with specific sedimentary units. Shennan (1982) outlined the errors that become incorporated into age/altitude graphs and advocated a generic altitudinal error margin of $\pm$ 0.3m. This was introduced into calculations made for the Fenland study discussed in this paper, and it was stressed that such calculation of error should also be applied when making regional comparisons. This does not seem to have been widely undertaken.

Heyworth and Kidson (1982) studied the key problem areas in sea level analysis; in fact, ten specific areas were outlined (see Table 3). Some (i.e. leveling problems) discuss points reiterated elsewhere in the volume (*Proceedings of the Geologists Association* Special Issue, 1982), however, this is one of the more detailed published papers documenting the issues. It also includes discussion of the fundamental assumption made elsewhere (i.e. Shennan 1982) that there has been no variation in tidal range through the geological record. Although it is considered that this assumption needs to be made in order to undertake RSL calculation, it is patently obvious from historical and archaeological records that it is not valid.

| Error code | Error type |
|---|---|
| A | Leveling |
| B | Identification of horizon to be leveled |
| C | Relation of water-table to sea level |
| D | Relation of present tidal levels at the site to those at the nearest Tide Table port |
| E | Variation of tidal range over time |
| F | Exceptional tides, storm surges, etc. |
| G | Consolidation of sediments as a result of gravitational compaction |
| H | Changes in the relationship between a sea level indicator and tidal levels |
| I | Sedimentation rates; relation to rates of sea level rise |
| J | Radiocarbon dating errors |

Table 3. Errors involved when calculating sea level, from Heyworth and Kidson (1982)

The issue of palaeotidal modelling is one that has received attention for some time. Jardine (1975) underlined the importance with the explicit recommendation that former tide levels be reconstructed. Nevertheless, some early workers disregarded this, for instance:

*"It is assumed also that the tidal range has remained more or less constant along the Lancashire coast during the Flandrian stage"* (Tooley 1978a, 23)

The work of van der Molen (1997) in Cape Cod identified a number of issues associated with tidal fluctuation in a modern salt marsh setting. He recorded significant distortions of tidal range within the Great Marshes system, particularly within long narrow tidal creeks, showing variation of up to 0.55m between MHW marks across the system (10x4km). This variation is caused in part by the geometry of the marsh system in combination with factors such as vegetation slowing overland flow. The applications of this work to palaeo sea-level modelling is clear: if variations of tidal range can occur within modern, relatively small systems on the basis of internal geometry, then the chances of significant change in tidal range occurring in dynamic systems over time, are high. Van der Molen suggests that sea level researchers should confine themselves to small salt marsh environments, preferably with 'direct and wide access to the sea' and that if large salt marsh systems are modeled then corrections must be made for tidal distortion

More recently, tidal range has been tackled by Shennan et al. (2000a, 2000b) in the LOIS project, where they found that tidal range has increased since the Early Holocene, but with only limited change over the last 6000 years. These data were used to recalibrate previously calculated sea level index points, increasing the differences between prediction and observation, underlining the need for further work in this area.

Compaction is perhaps the single largest source of error involved in conventional sea level analysis. Nevertheless, it is rarely discussed in detail within papers examining RSL change. Heyworth and Kidson (1982) discuss autocompaction and the desirability of applying correction factors where possible, citing reductions of a half in the thickness of woody peats and 90% with *Sphagnum* peats. The evidence for these values is not cited, however, the importance of compaction is not in dispute here. The likelihood is that sea level index points are consistently being calculated too low because of compaction, yet few researchers seem to apply correction factors, probably through lack of conviction that they work (Ian Shennan, pers comm.). Haslett et al. (1998) are amongst a very few that have attempted to model compaction on the basis of altitudinal differentials. Tooley had examined compaction earlier (1978b), and also indicated that it was possible to calculate settlement under a known load, citing the earlier work of Jelgersma (1961) and MacFarlane (1965). Although Tooley discusses the problems in detail, he ends by stating that it would be impossible to calculate and correct for compaction in coastal areas showing varying degrees of consolidation. His subsequent statement that the importance of this issue is paramount is therefore a little weak. The problems of compaction were further addressed in 1986 (Greensmith and Tucker 1986), but little was added to the discussion other than to reiterate the significance of the problem and to state that researchers should exercise great caution. The other issues listed below (Table 3) and in other works (for instance Tooley 1978a; Shennan 1986) do not have such an impact on calculation of RSL; some indeed have become less of an issue, such as leveling, owing to improved technology, such as differential global positioning systems (GPS).

More recently, Allen (1999, 2000) has readdressed autocompaction, looking specifically at coastal and marsh situations and emphasizing problems with interdigitating 'sediment couplets' of peat and silt in mid Holocene sequences. He also calculates the effect that autocompaction can have on deposition rates and conversely, the effect land reclamation can have upon compaction. He dismisses previously used soil mechanics models (i.e. Paul 1998 and see Smith 1985) created to decompact sequences as '*highly idealized*'. Allen examines the use of numerical simulations to gauge the effects of autocompaction and identifies several key factors with reference to RSL studies; namely that calculated rates of RSL rise are greatly affected by autocompaction, as are rates of sediment deposition. His final conclusion (Allen 1999) states that:

> '*Autocompaction affects the meaning of conventional sea level index points to a degree that can no longer be ignored.*'

Nevertheless, Allen does not suggest any practical methods of decompacting sequences and this issue is still largely undiscussed, with the exception of examples such as Waller et al. (1988, 1999) who compared dating and events in the pollen sequence across a number of cores in the Brede Valley, Romney Marsh and estimated compaction values above thick peats. They attributed values of between 46 and 75% and indicated that these were minimums. These are, therefore, reasonably comparable with the figures of 50% suggested by Devoy for compaction of peat at Tilbury (1982).

The work of Gehrels et al. (1996) on the coast of Maine, applied a standard compaction error of 50-100mm in the creation of index points, however, there is an admission that the error factors used, were in many cases, best guesses. Earlier work in the area (Gehrels and Belknap 1993) had circumvented the issue simply by prioritizing basal peats over incompressible substrate. This may indeed be the best answer to the problem, however, in areas of deep sequences, it is a method likely to lead to relatively short phases of the entire systems history being examined.

## Summary

This chapter provides an overview of how the methods used to undertake the analysis of sea level change have evolved. This travels from the initial quest for global resolution through the rubicon of impossibility to more achievable targets of small scale local to regional detailed analysis. Although suggestions for change have been made, i.e. 3-D graphs and tendency diagrams, it is noticeable that the present mechanism is still primarily to produce age-altitude graphs and some sea level curves. This has been the prevalent form since at least the 1970's, and has changed little, with the exception of dividing the graphs between the different types of index point.

Also noticeable is the thinness of research into how to resolve some of the key problems with the method, such as compaction and the assumption of a constant tidal range. These are both crucial and yet there have been few attempts to provide concrete mechanisms of resolving them. The basic and most reliable method is to establish exactly where the tidal levels were. Tidal range is an area where archaeologists and historians have been active (see Chapter 11), because knowing where the dry land ended is vital to an understanding of human settlement. Yet sea level analysts, although often collaborating in research with archaeologists, do not appear to have used the (albeit limited) data obtained from excavations or historical tide gauge records. In the absence of such data, it is relatively difficult to calculate past levels, but is possible, as shown by the work of Shennan et al. (2000a). Without this type of research, sea level index points can be miscalculated by the order of several metres.

With reference to factoring in altitudinal corrections for estimated compaction, this should be possible based on known densities of different sediment types and the density of the recovered material. Compaction and consolidation are some of the largest issues associated with sea level calculation but has not yet been conclusively resolved. The combined problems of tidal range and compression must seriously affect the altitudes presented on age-altitude graphs by lowering the altitude of index points by several metres. Yet much energy has been spent on refining calculations of reference water levels, with errors, which are in millimetres. These two issues are obvious priorities for future research.

## 2.3 Sea level research in the Thames estuary

### Introduction

This section is intended as a review of the literature concerning RSL change within the Thames estuary. It is considered beyond the scope of this section to examine research undertaken in the entire British coastal zone or other estuaries although comparison will be made between the results of this study and other published research in Section III. Following the introductory section, the major models of sea level driven sedimentation in the Thames estuary are outlined and examined. This section is concluded with a review of research undertaken specifically by archaeologists on the subject of relative river levels in central London, using archaeological methodologies associated with structures and stratigraphic evidence.

### Thames Estuary Research

The Thames estuary has long been a focus for study of river dynamics (e.g. Spurrell 1885; 1889; Whittaker 1889), particularly in the outer estuary, (from Tilbury downstream). These describe the sequences encountered in various exposures, such as the excavation of several docks, including those at Tilbury (1 on Figure 4), with diagrammatic section drawings (Whittaker drew three peat horizons at Tilbury, reproduced by Spurrell in 1889). As well as providing the earliest reasonably scientific information on Thames sedimentation, these papers provide an important record of the excavation of the London docks, including highly evocative descriptions of buried forests, faunal remains and artefacts.

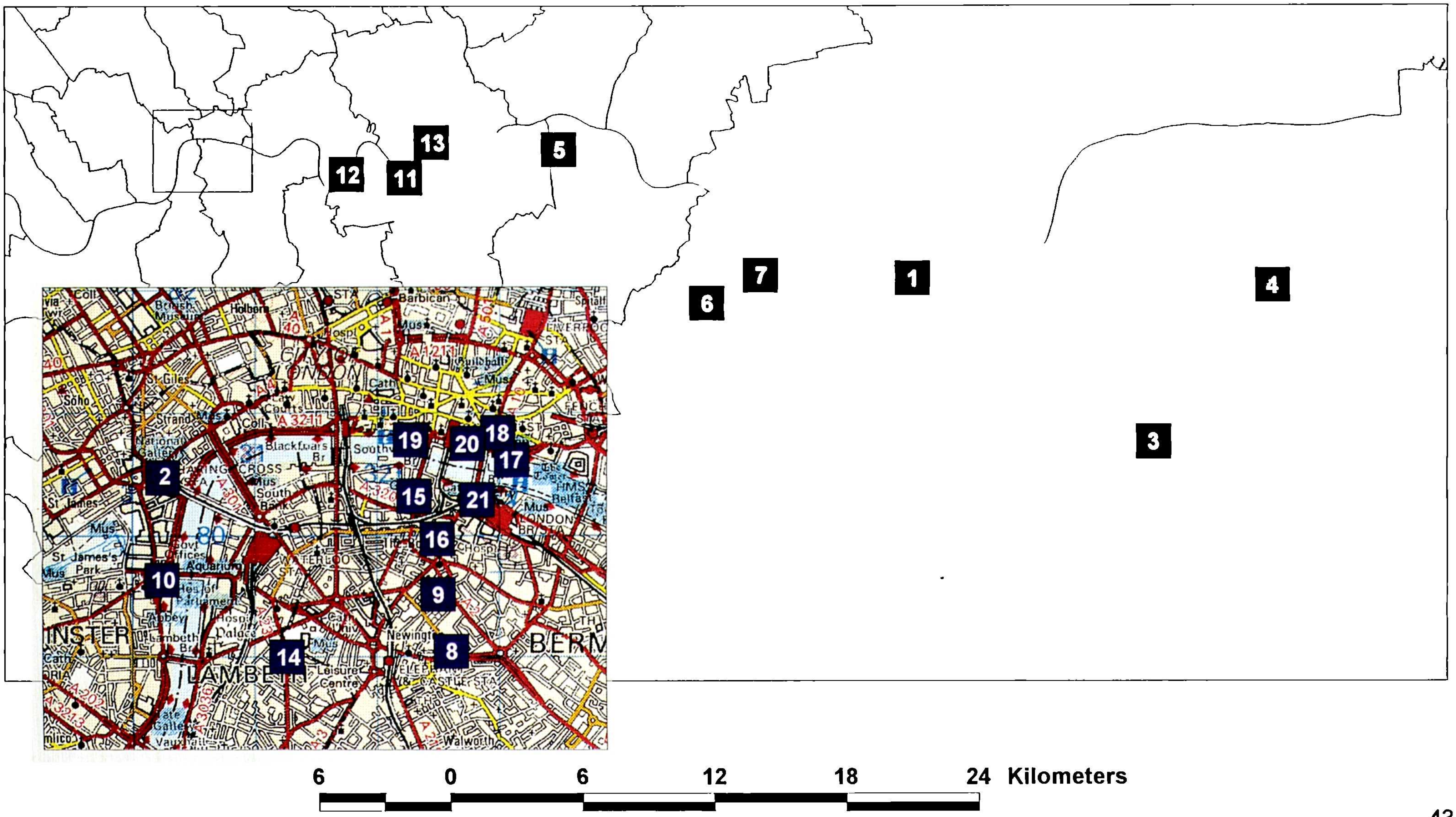



Figure 4. Location map of London sites mentioned in chapter 2.3

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Tilbury | 6350 | 7570 |
| 2 | Charing Cross | 3025 | 8050 |
| 3 | Medway Valley | 7500 | 6800 |
| 4 | Isle of Grain | 8000 | 7500 |
| 5 | Crossness | 4775 | 8150 |
| 6 | Dartford | 5450 | 7440 |
| 7 | Broadness | 5700 | 7580 |
| 8 | Bermondsey | 3450 | 7940 |
| 9 | Southwark | 3250 | 7950 |
| 10 | Thorney Island | 3022 | 7962 |
| 11 | Silvertown | 4050 | 8035 |
| 12 | Blackwall Dock | 3825 | 8025 |
| 13 | Custom House | 4130 | 8110 |
| 14 | Lambeth | 3125 | 7900 |
| 15 | Courage Brewery | 3241 | 8020 |
| 16 | Borough High Street | 3255 | 7995 |
| 17 | Trig Lane | 3301 | 8069 |
| 18 | Pudding Lane | 3294 | 8072 |
| 19 | Queenhithe | 3230 | 8079 |
| 20 | Regis House | 3288 | 8072 |
| 21 | London Bridge | 3280 | 8030 |

Table 4. Sites shown on Figure 4

One of the earliest papers presenting a sequence of sedimentation (King and Oakley 1936) concentrates mainly on the Pleistocene succession. In addition, Mesolithic peat and alluvial sediments associated with a 'Tilbury' stage are described as well as a pre-'Tilbury phase' of erosion linked with post-Glacial rebound and correlated with the *Ancylus* Lake phase of the Baltic chronology. This description uses the sequence at Tilbury Docks recorded originally by Whittaker (1889, 468), quoted in Spurrell (1889). It is not, therefore, a new dataset. Furthermore, this pre-Tilbury phase is attributed to deposits as far apart as Charing Cross (2 on Figure 4), and the Medway Valley (3 on Figure 4). Also there is no real attempt to characterize the processes leading to the formation of this sequence, which Spurrell did attempt nearly fifty years before. Nevertheless, this is the first publication to identify Tilbury as the type-site for Holocene sedimentation in the Lower Thames.

Research continued on the outer estuary with a paper by D'Olier (1972) examining subsidence and sea level variation. Using a combination of offshore seismic data and Jelgersma's (1961) sea level curve for the North Sea basin, D'Olier mapped the shoreline of the outer estuary on the basis of calculated sea level and seismic data for several dates in the Early Holocene, tracking the progression of the sea into the modern geographical area of the estuary. He then tracked sea level rise/crustal subsidence by measuring the amount of sediment that has entered the estuary since it was first flooded *c.* 9000 years ago by tidal waters. He estimated that the measure of sea level rise/subsidence was 127mm per century for 9000 years in that sedimentation rates and RSL remain in equilibrium. This approach is subject to problems, particularly associated with the difficulty in accurately calculating the amount of sediment currently contained within the estuary and measuring the actual (average) area of the Thames estuary when it has almost certainly been substantially remodeled over the period in question.

When the figures are extrapolated, this allows for a rise in RSL of just over eleven metres since 9000 BP (approximately), which, when compared with more recent work seems to be an under-estimate. For example, Devoy (1979) indicates a rise of 20m during the Holocene. Akeroyd (1972) indicates that river levels have increased 11m since the Neolithic, although she states that work in the region has been subject '*more to speculation than hard reason*'. Her figures are based on archaeological findings (Roman structures) and sporadic palaeoecological research, which leads her to the conclusion that the tidal head in the Roman period may have lain downstream of Crossness (5 on Figure 4). She also suggests, based on the work of Lambert (1920) that there has been a 2m rise in high water since the Roman period, but also cites evidence from Brentford (a hut on the foreshore, recorded by Wheeler in 1929) to show a 4.5m increase since the Iron Age/Roman period. These statements are problematic and further confused by no reference to which part of the Roman period she is referring to. Another problem is that she seems to use land subsidence and river/sea level rise interchangeably when referring to changes in altitude without distinguishing between the two. Nevertheless, it has since become apparent that there are striking changes in river level within the Roman period (Brigham 1990, Watson and Brigham 2001, 26), so it is possible that many of Akeroyd's contentions could be reconciled depending on the absolute date of the structures she cites.

The next major work also focused on the outer estuary (Greensmith and Tucker 1973), and indicated a cyclical sequence of transgressions and regressions, defined as retreats and advances of both salt marsh and marine conditions. Emphasis was placed on the probable complexity of the controlling factors, summarized as regional subsidence combined with climatic and sedimentological factors. However, sea level fluctuation was put forward as one of the more significant elements controlling sedimentation. A model constructed of five regressive and six transgressive episodes was proposed (see Table 5), including the present and initial Flandrian transgressions, the latter thought to have commenced at approximately 8900 BP (the date the rising waters are thought to have impacted upon the outer estuary, based on Jelgersma (1961) and D'Olier (1972).

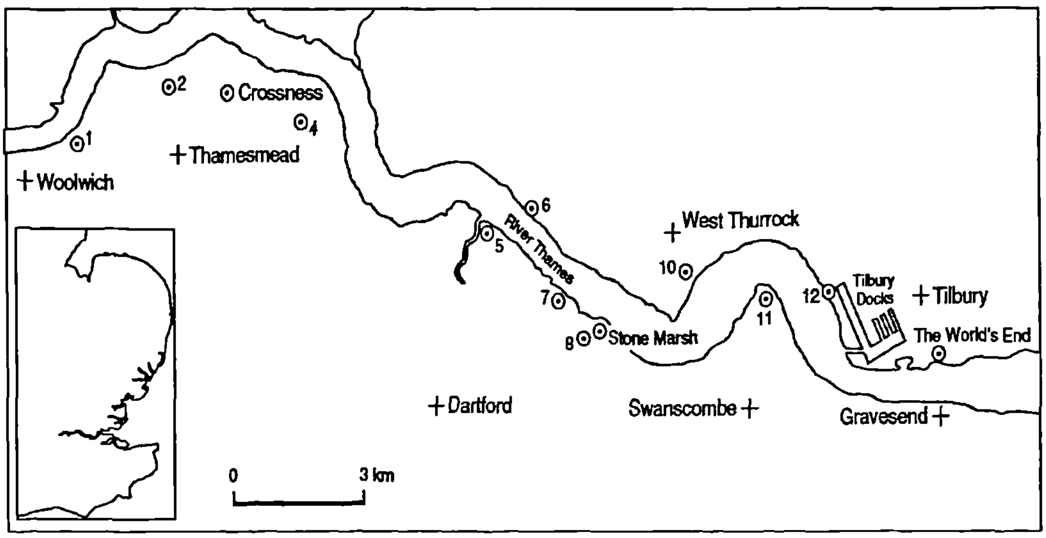
| Transgression | Date (BP) | Continental equivalent |
|---|---|---|
| VI | 300 | - |
| V | *c.* 1400 | Duinkerke Beds |
| IV | *c.* 3350-2700 | Duinkerke Beds |
| III | *c.* 4000 | Duinkerke Beds |
| II | *c.* 7500 | Calais Beds |
| I | ? 8900 | Ostende Beds |

Table 5. Greensmith and Tucker's 1973 model of Thames transgressive events

The model was constructed on the basis of facies properties (organic versus inorganic) combined with analysis of faunal material. The use of marine molluscs formed a substantial part of the sedimentary modelling, using the stratigraphy of marine molluscs to indicate transgressive events. The earliest phases of the model are dated through radiocarbon with archaeological data used for the later period. A regression is indicated for the Roman period, with a subsequent transgression in the Saxon period, something that has since been observed elsewhere (Sidell 2001; Watson and Brigham 2001). The oscillating nature of river levels was identified and emphasized; considered a product of fluctuations in RSL and additional coastal uplift and/or accretion. Although the difficulty in establishing exact causes is emphasized, eustatic sea level change is suggested as the prime control with reference to sedimentation in the outer estuary. Furthermore, the presence of "overconsolidated layers" is interpreted as reflecting a drop in RSL, indicating significant changes in processes within the estuary. There are some problems with this paper, most notably in the use of marine mollusc horizons to indicate transgressive events since these could be deposited on salt marshes by mechanisms other than actual sea level rise, such as storm surges or erosion from channels or creeks nearby. Also, the cheniers where these deposits are found do not necessarily undergo the same sedimentation processes that are found on the estuary sides, and so it is dangerous to extrapolate sequences from the cheniers to an estuary-wide model. The argument for a drop in RSL is also weak. They subsequently re-visited the subject (Greensmith and Tucker 1976), giving much more detail on the sedimentology and mineralogy of the sequences. The chronological model remains, but in addition this second paper produces maps outlining the suggested movement of the coast and sea around the outer estuary.

### *The 'Devoy model'*

The most important study completed on Thames RSL is that of Devoy (1977a,b, 1979), who worked on sites stretching from the Isle of Grain (4 on Figure 4), to Crossness (see Figure 5). A sequence was constructed using facies-based modelling and ecological reconstruction. The 'Tilbury' model has since been widely regarded as the seminal work for the Lower Thames (Haggart 1995).




1. Woolwich East 2. Church Manor Way 3.Crossness 4.Norman Road
5.Longreach 6.Harrisons Wharf 7.Littlebrook 8.New Dartford Tunnel
9.Stone Marsh 10.West Thurrock 11.Broadness Marsh 12.Tilbury, Worlds End

Figure 5. Devoy's study area, from Haggart (1995)

Interdigitating peat and estuarine clay-silts were identified throughout the study area, classified as 'Tilbury' (organic) and 'Thames' (minerogenic) facies (see Figure 6). The Thames deposits were considered to be equivalent to periods of RSL rise and the Tilbury sediments to drops or decreases in the rate of sea level rise. The model commences with the initial rapid rise in RSL following the input of meltwaters at the end of the Devensian. This saw an increase in RSL of over 15m between c. 11500 cal BP and c. 6850 cal BP, which is paralleled elsewhere in south eastern England (Long and Tooley 1995).

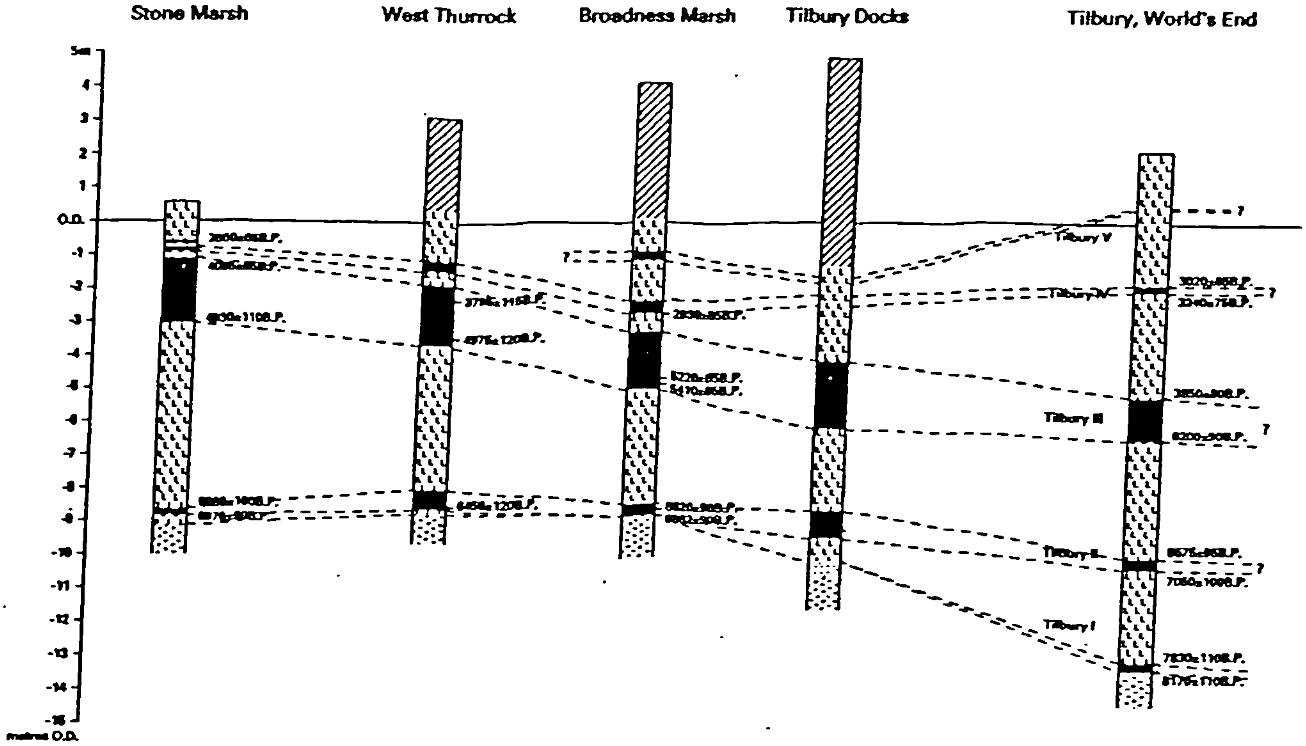
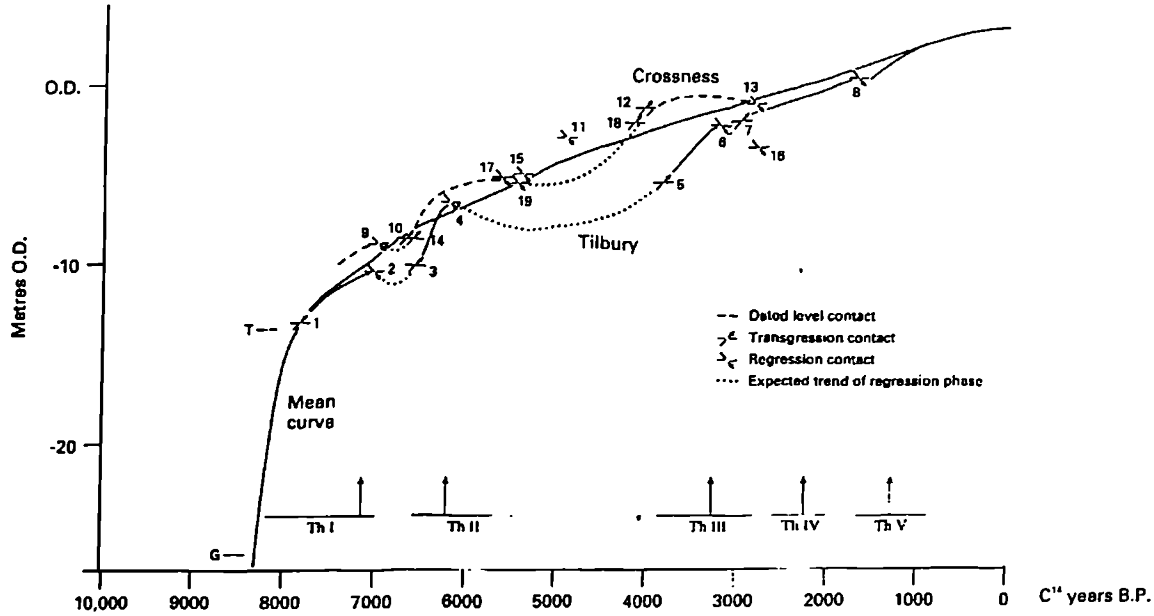



Figure 6. Stratigraphy used in the 'Devoy model' from Haggart (1995)

Devoy constructed two age/altitude curves of RSL movement (see Figure 7): one for Tilbury (mid estuary) and one using data from Crossness, Dartford (6 on Figure 4), and Broadness (7 on Figure 4). These indicate that RSL has oscillated through time against a background trend of generally rising sea level. Initially, at the beginning of the Holocene, this rise is thought to be rapid, and compares with data from adjacent geographical areas, such as the Netherlands (Jelgersma 1961) and Northern Britain (Tooley 1976). A drop followed this for c. 300 years to -10m OD, rising again to -5m OD over the period 6600-5500 radiocarbon years BP. This was succeeded by a period of rise between 4000-3500 radiocarbon years BP to between -1.5m and -2.5 OD, followed by a minor regression, Tilbury IV, which was regarded as asynchronous and variable in altitude (where present). There was a transgression recorded at Tilbury to 0.4 OD, taking place at c.1750 radiocarbon years BP, followed by a further regression, Tilbury V, also only recorded at Tilbury (see Table 6). The current transgression, Thames VI was thought to indicate rapid rise in MHWST, possibly as a result of (anthropogenic) influence within the estuary.




Relative sea-level curves for the inner Thames estuary. Curve 1 is from Tilbury. Curve 2 is from Crossness, Stone Marsh, Dartford Tunnel and Broadness Marsh. Points 1-8 are from The World's End borehole (point 8 is a 'pollen date'). Points 9-13 are from Stone Marsh. Points 14-16 are from Broadness Marsh. Points 17 and 18 are from Crossness. Point 19 is from the Dartford Tunnel. The Isle of Grain date is represented by G.

Figure 7. Sea level curves, from Devoy (1979, figure 29)

The biostratigraphy of the Devoy model was constructed using pollen and limited diatom evidence (diatoms from Tilbury only). In summary, the peat sequences are recorded as spatially variable; both wood and monocot peats, with the downstream sites tending to be composed of saltmarsh and *Phragmites* peats. This is not the case from Broadness upstream where there is a development within the peats starting with wood fen, through *Phragmites* to saltmarsh peats. Nevertheless, clear correlation was made between these peats.

Although the two curves demonstrate similar trends at similar times, there is a marked difference in altitude, which is attributed to differential downwarping between Crossness and Tilbury, variation in tidal amplitude and sediment discharge from upstream. Subsequently, Devoy (1980) correlated the model with the earlier model proposed by Greensmith and Tucker (1973). Emphasis was placed on lateral variation of the sequence, which shows basal peats forming within the inner/mid estuary, whilst further out, minerogenic deposits accumulated first on the gravel surfaces. Tidal waters are indicated as having reached at least Tilbury by *c.* 7700 radiocarbon years BP. The age model was subsequently modified (Devoy 1982), and the following sequence proposed:

| Event | Commencement | Cessation |
|---|---|---|
| Thames V | *c.* 1600 cal BP (-0.75- +0.44m OD) | no data |
| Thames IV | 2750 cal BP (-1.8-0.8m OD) | No data (-0.9- +0.4m OD) |
| Thames III | 4250 cal BP (-6.7- 1.9m OD) | 2900 cal BP (-2.0 - 1.0m OD) |
| Thames II | 7550 cal BP (-12.3- 6.8m OD) | 5700 cal BP (-6.9- 3.0m OD) |
| Thames I | 9200 cal BP (-25.5- 13.2m OD) | 7800 cal BP (-12.5 - 8.0m OD) |

Table 6. Chronology and altitude of the Thames units (Devoy 1979, 1980)

The Devoy model was discussed by Shennan (1987), highlighting the issues of in-estuary differential between the two curves and the examination of crustal residuals. He suggests that consolidation in the study area is not likely to be a significant factor causing the difference between Devoy's curves and the regional eustatic sea-level curve. Tidal changes and decreased subsidence are identified as at least partly responsible, but are not put forward as conclusive explanation of the problems with the Tilbury curves.

Long (1991) identified a number of problems associated with the model. One of these was identified as the large altitudinal range of each deposit, causing problems with correlation across the study area (Long 1991, 42), compounded with spatial variation in the type of peat identified as the main Tilbury units, i.e. wood peat upstream to *Phragmites* at Tilbury/Broadness. Although Long specifies Devoy's possible causes for these changes, Long identifies the problems of commercial logs as a possible contributory factor (1991, 43). He further discusses some problems with the interpretation of the sedimentary sequences, with reference to inwashing over the sites and the difficulties of establishing indicative meaning in such cases. There are also issues with the chronology; Long quotes a fundamental sentence from Devoy (1977b, 150):

*The radiocarbon dating of transgression and regression contacts of the biogenic levels can be confusing.*

Long notes that Devoy stated that some of this confusion could relate to errors in the field or that the dates themselves might be 'wrong'. It is notable that the dating of the Devoy model remains incomplete.

Haggart (1995) subsequently identified several problems with the model. Scrutiny of the timing of events with relation to the stratigraphy indicates that the regressive contacts occur chronologically within periods of RSL rise. The implication (supported by the biostratigraphy) is that some periods of organic sedimentation (particularly Tilbury III) occurred under conditions of rising RSL. The earlier suggestions of differential crustal movement (Devoy 1979) are questioned following reappraisal of several index points, which could represent rising RSL. Additionally, index point five is identified as altitudinally unreliable on the grounds of compaction and erosion. Haggart suggested that the discrepancy between the two curves constructed by Devoy would be eradicated if correction is made to the height of this point (an increase of 3m), and the other points mentioned were treated as indicating a positive rather than negative tendency. Although there are data supporting the suggestion that some of the organic sedimentation does occur during phase of RSL rise, the suggestion that a correction of 3m could 'fix' the problems appears unsound as it seems unlikely that a three metre difference in factors such as levelling errors/compaction would only occur in one location. It is also perhaps relevant to note that when the Tilbury site was cored in 2000 (Sidell and Long 2000), the upper contact of the upper peat, thought to be Tilbury IV, showed no sign of erosion (see Figure 8).

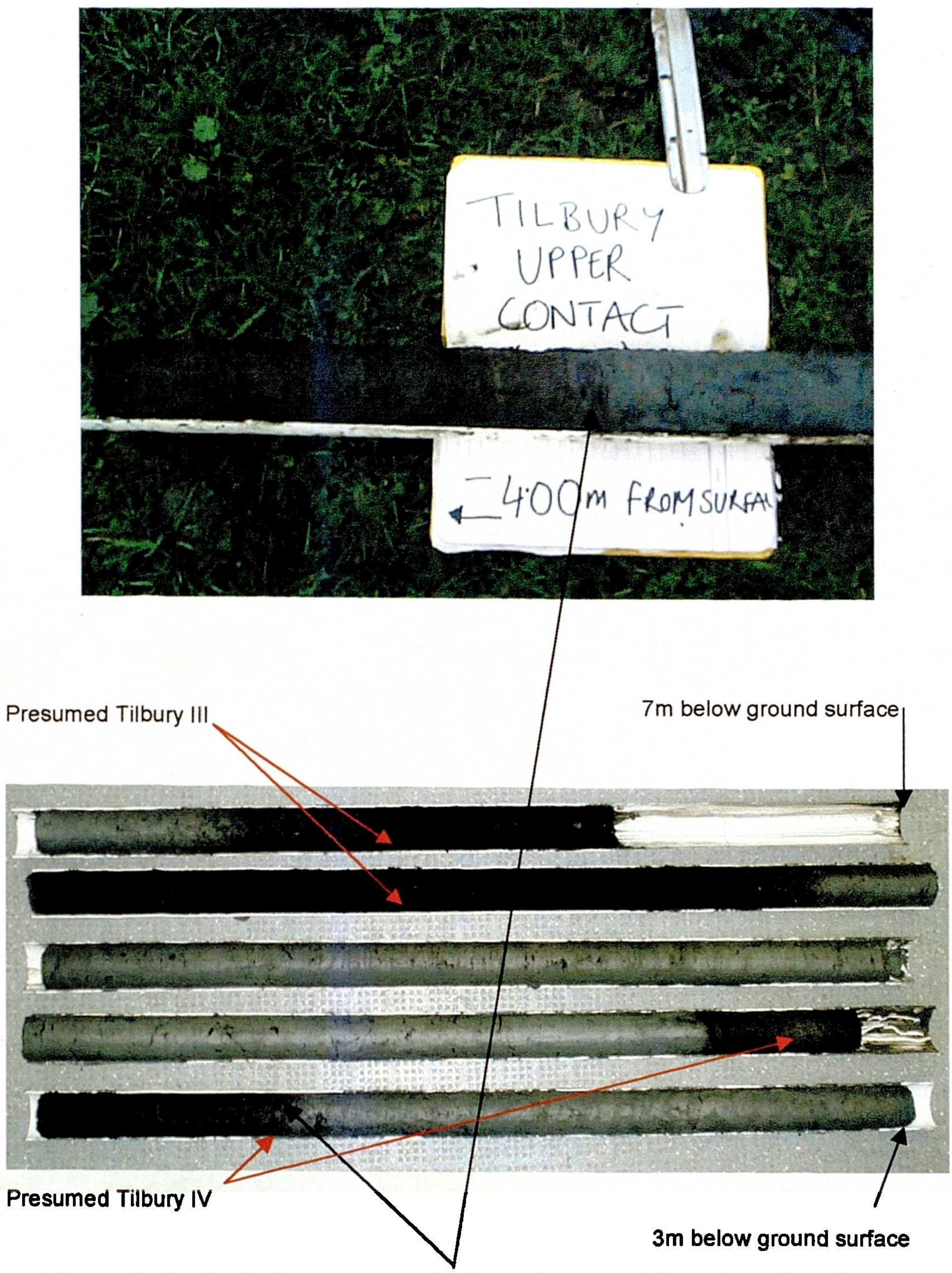



Figure 8. Contact of upper organic deposit to overlying mineral sediment, recorded at Tilbury as part of an IGCP project 437 field trip, December 2000 (Sidell and Long 2000). Each core is 1m long

The issue of crustal movement which Devoy cited as a possible cause for variation within the study area was taken up by Long (1995), who indicated the division evident between models proposed in support of, (for instance, Devoy 1979) and against differential crustal movement (Bridgland 1988). This latter paper considers longer chronologies that include Pleistocene deposits and notes no significant divergence of Pleistocene river terraces in the middle and lower estuary which might be expected where long term differential crustal movements are evident. Evidence of sea level and crustal change from the Thames, Essex and east Kent was examined, based on sea level index points calculated from these areas. Downwarping, as suggested by Devoy as a possible explanation for altitudinal inconsistency, was rejected on the grounds that the older points should therefore plot lower in the middle than the inner estuary, which is not the case. Some crustal movement in the middle estuary between 6-4000 radiocarbon years BP was thought possible. A further suggestion from the Devoy model is that differential sediment compaction lead to the observed discrepancies. This is also discounted as some consistency along the transect might be expected. Nevertheless, all sites upstream of Tilbury differ significantly from the model based on the sequence at Tilbury, and there are no detailed records of sites in the downstream teaches, so it is not possible to exactly state what is the root cause of the problem, but it is obvious that there is a fundamental problem at Tilbury itself.

### *Post-Devoy models*

River level change, with reference to topographic development in the central London floodplain was addressed by Nunn (1983), who, whilst discussing northward migration of the main channel, constructed a five-stage sequence of river development. This was, with some unoriginality, named Thames I-V (see Table 7) and discussed the changing location of the main channel and tributaries in detail, concluding that sea level change was a major factor leading to local channel migration. His model is directly linked with Devoy's Tilbury stages, and correlated with RSL rise, giving specific altitudes for MSL associated with the timing of the Thames (after Nunn) and Tilbury (after Devoy 1979) stages. However, this work is largely based on historical sources and published data with no new geomorphological information. Historical data is always open to doubt, as information has potentially been badly recorded initially and then poorly transcribed/published. Furthermore, early maps are unlikely to have been strictly accurate. Therefore, Nunn's work is not considered to add significantly to the body of data on the Thames but did establish an unfortunate precedent for direct correlation to Tilbury.

| Stage | Date range ($^{14}$C years BP) | Sea level (m. OD) | Contemporary riverine features |
|---|---|---|---|
| Thames V | 1750-present | -0.9-0.0 | Present artificial channel |
| Thames IV | 2800-2600 | -1.8-0.8 | Elephant and Castle channel |
| Thames III | 5400-3850 | -5.2-1.9 | - |
| Thames II | 6882-6575 | -10.07-6.8 | Rotherhithe channel |
| Thames I | 10250-8200 | -25.5-13.23 | Camberwell channel |

Table 7. Thames I-V, after Nunn (1983)

The foreshore of the outer estuary was examined in detail through the Hullbridge Survey (Wilkinson and Murphy 1995), most of which was concerned with the Essex coast, but penetrating to the edge of London (see Figure 9). The use of only the foreshore constrained sea level analysis, which was therefore based on the data from Devoy (1982) to which new point data were added (Wilkinson and Murphy 1995, 214, figure 129), subsequently incorporated by Long in his 1995 curve. Generally the new data plot altitudinally above the Devoy points, but the Hullbridge sites are plotted as straightforward OD heights rather than being reduced to MSL, and therefore it is unsurprising that there is an altitudinal differential. Furthermore, it was noted that there was variation within the sequences of the Thames, Roach, Crouch and Blackwater estuaries. The analysis of the dated sites is thought to lend credence to Devoys model simply on the basis of the archaeological changes. This seems optimistic and the data do not appear to have been examined rigorously enough to extrapolate to a detailed model of sea level change.

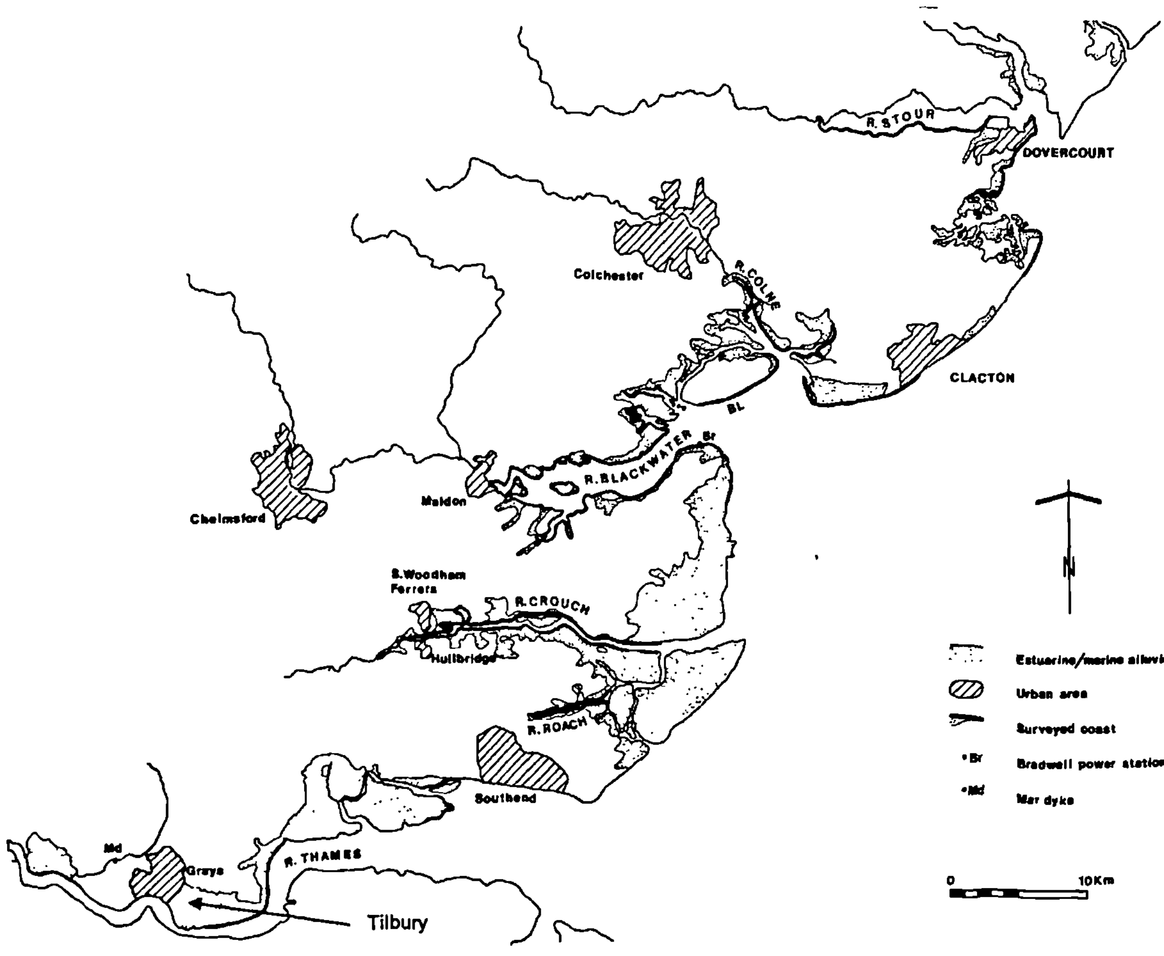



Figure 9. Hullbridge survey study area, from Wilkinson and Murphy (1995)

Woodbridge (1998) examined a sequence from Bermondsey (8 on Figure 4), central London, making a further comparison with the Devoy model. He acknowledged the issues involved in doing this, but nevertheless directly correlated the sedimentary units present at Bermondsey with the Tilbury sequence. Diatom analysis was undertaken and one radiocarbon date was obtained. The conclusions of the work were that much of the sequence could be closely correlated with Tilbury, but that tidal waters were present upstream of Bermondsey in the Late Mesolithic (5400±100 BP; 4450-3980 cal BC - no laboratory code published) with river levels (no specific level identified) at an altitude of -3.49m OD. Woodbridge does indicate that such a result was unexpected and in contrast with other published information such as (Milne et al. 1983; Sidell et al. 1995), but states the possibility that it is correct. Nevertheless, the scenario is unlikely in the face of the evidence gained from Southwark (9 on Figure 4), which suggest that tidal waters only migrated through the area in the Middle Bronze Age (Sidell et al. 2000). Other work, (Long 1995) does not compare well with Woodridge's work and suggest that his data are anomalous and may have been caused by rare tidal surges or even contaminated samples resulting from sampling on the foreshore. Nevertheless, the altitude is a raw measurement and has not been reduced to MSL and may be more comparable with the various sea level graphs than initially appears in his paper.

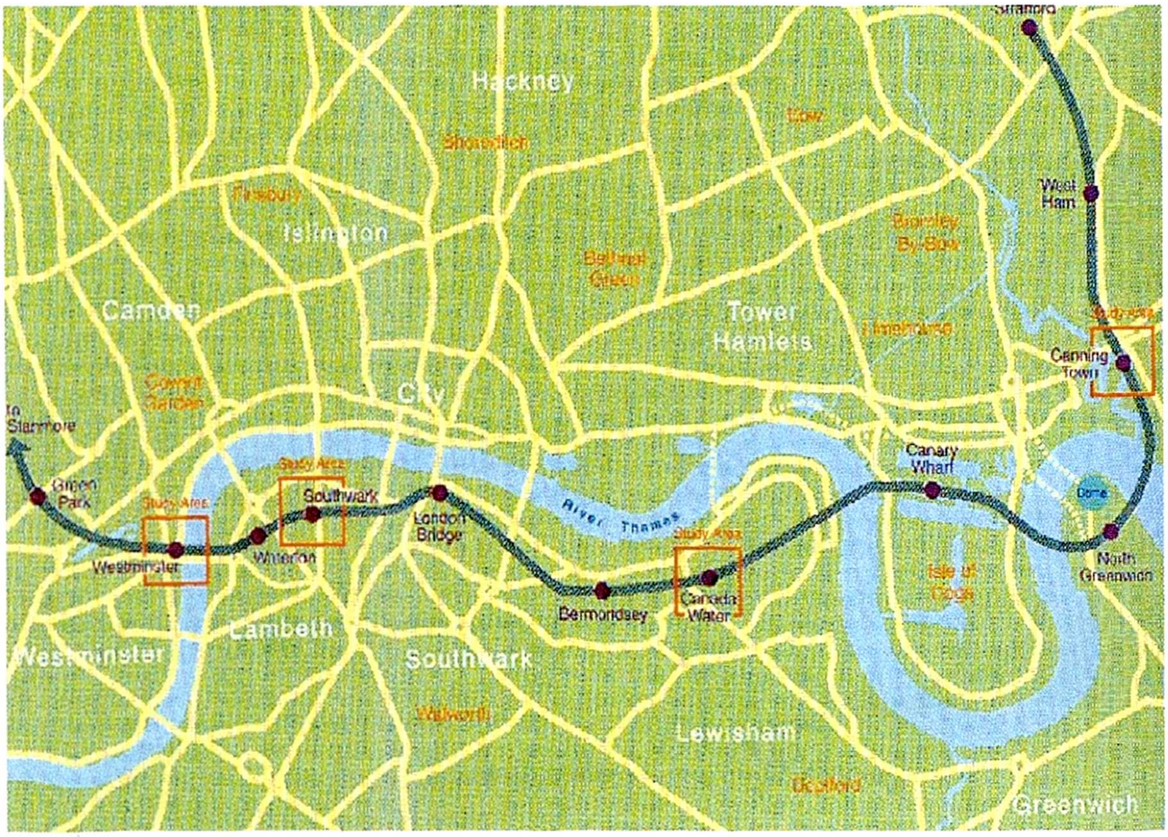
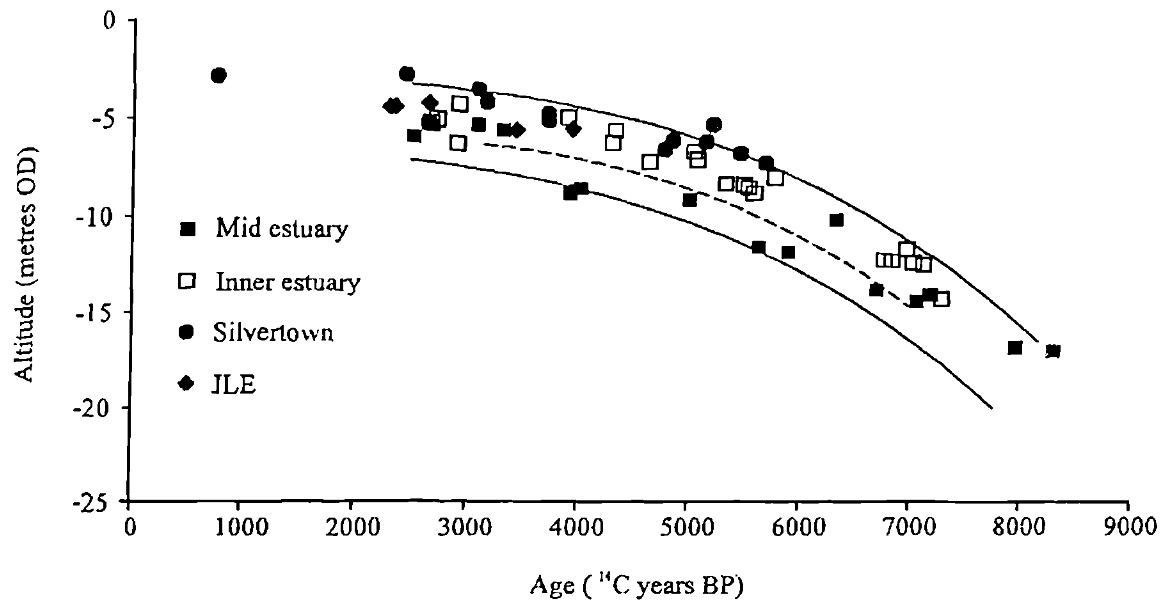



Figure 10. The Jubilee Line Extension, along thick arrowed line

The recent work on the Jubilee Line Extension in central London (Sidell et al. 2000) (see Figure 10) has added some new data (Figure 11). The project was undertaken within the sphere of developer-funded archaeology and was therefore subject to the usual constraints of limited time and funding. Nevertheless, sufficient sites were examined to gain an impression of changes over a 15km stretch of the river and several thousand years. A three stage model of riverine development was proposed, examining the changes from the braided Late Devensian river, through a meandering single-channel freshwater river of the Early-Middle Holocene, depositing sands and forming the well-known eyots, such as Thorney Island (Wilkinson et al. 2000, 10 on Figure 4). The final stage is the tidal river, which reached central London by at least 1200 cal BC (c. 3200 cal BP). The project created four valid sea level index points. These are from intercalated sequences; none are from 'basal' peats and therefore cannot be viewed as of the highest quality, nevertheless, they fall within the upper range of the dates generated by Devoy (1979), Long (1995) and (Wilkinson et al. 2000, see Figure 9). The points are more closely comparable with those from Devoy's inner rather than mid estuary/Tilbury curve. On the whole they plot slightly lower, altitudinally, than those from Silvertown (Wilkinson et al. 2000, 11 on Figure 4), which is further downstream. Although this appears anomalous, it may be a factor of individual errors (i.e. results of compaction and radiocarbon error) associated with each point. What these projects have shown is a strengthened case for assuming there is a problem at Tilbury itself, where the both the stratigraphy and age/altitude data points diverge from the general trend consistently represented from all other sites. It certainly casts doubt on the appropriateness of using Tilbury as a type-site for a larger geographical area than the outer estuary or even a type-site at all.

The most recent model proposed for the Thames estuary (Long et al. 2000; Long 2001) indicates that Holocene sedimentation can be placed within a three-stage sequence constructed on the basis of estuarine development (see Figure 12). The model opens with the Early Holocene rapid rise in RSL, followed by estuary contraction between roughly 6850 cal BP and 3200 cal BP. This is shown by a seaward and upward expansion of semi-terrestrial marsh deposits along the river margins and in the tributary valleys. This contraction is attributed to a drop in the rate of RSL rise leading to peat accreting slightly above the rising tidal waters. The final stage of the model is an increase in the rate of sea level rise, continuing to the present day, presenting itself as a series of estuarine clays that submerged the earlier marshes as the estuary expanded once more.




Index points reduced to MTL. Error bands are based on altitudinal errors applied to the MSL calculations. Dashed line separates Tilbury (mid estuary) below inner estuary sites

Figure 11. Current age-altitude curve for relative sea level fluctuations in the Thames estuary based on published data, from Long (1995), modified by Sidell et al. (2000)

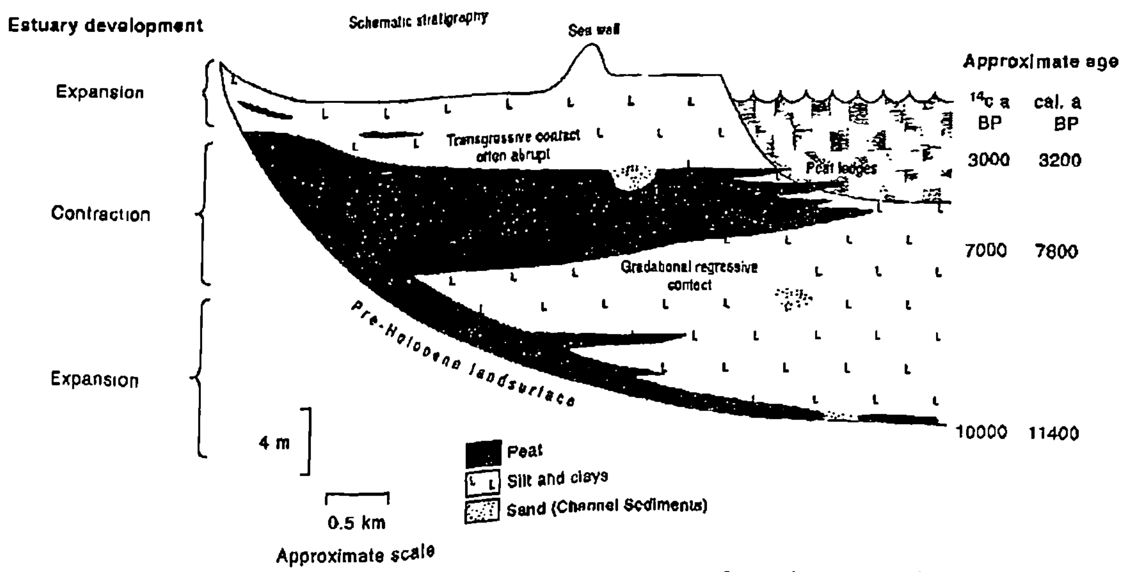



Figure 12. Summary estuary development diagram from Long et al. (2000)

The model is deliberately simplistic and is based on the Thames, the Severn and Southampton Water. Although these do all vary in nature and scale, by concentrating on the broader scale, a workable model has been produced, which certainly for the Thames is sufficiently accurate to base more detailed discussions on. Yet it throws up fundamental questions such as what caused the mid-Holocene expansion of the wetlands/reduction in the rate of sea level rise and what subsequently reversed this trend. Until these questions are answered, it will not be possible to fully explain the processes affecting RSL change in the Holocene Thames.

## Summary

This section has attempted to draw together the current published information on the changing levels in the Holocene Thames undertaken within the geological sphere. Some of the discussion will be expanded upon later in this thesis, but this stands as a guide to current thought. As has been shown, there are problems with the models that exist for both the sedimentary and sea level history of the Thames, but these issues are also to be found in other areas where models are few and research has not been exhaustive.

The work of Devoy remains today as the key piece of research for the estuary and one that is still used by both archaeologists and geomorphologists. Its drawbacks have been examined in some of the current literature on the Thames, included in the two recent fieldguides (Haggart 1995; Long 2000), but even with some problems, it remains the most comprehensive study on the subject. Nevertheless, the type-site is obviously anomalous, leaving the model poorly founded and only of limited application. The stratigraphy here is simply not seen in the inner estuary, where most sites exhibit only one peat horizon. Furthermore, the dating across the study area is inconsistent, and poorly resolved after the formation of Tilbury III. This reliance on the Devoy model is understandable because the work has not been revisited or replaced since the early 1980's. Small local studies have taken place, but with little attempt to model RSL, either through shortage of data, or, on the part of archaeologists, a concentration upon more anthropogenic issues. Nevertheless, the work of the archaeologists is a useful contribution and is outlined below and discussed further in Section III.

## 2.4 Sea level change and archaeology in London

The Thames has influenced the central London region ever since it was diverted from its more northern course during the Anglian glaciation. Sites such as Boxgrove in Sussex (Roberts et al. 1997) have shown that people were present in Britain in pre-Anglian stages but it is not until the Holocene that *in-situ* anthropogenic activity took place on a substantial scale within the Thames basin. The earliest studies of 'alluvial archaeology' can be traced back several centuries and include work by Blandford (1854), who noted the discovery of a canoe from these Thames alluvium. Further early work includes the papers of Spurrell (1885, 1889) and Whittaker (1889) mentioned above, giving detailed descriptions of finds made in exposures created during tunnel and dock digging. In fact the earliest description is of the Blackwall Dock (12 on Figure 4) in Samuel Pepys diary of September 1665 (Matthews 1972, 236), which records a series of trees within peat exposures. This section gives a brief account of the publications that have discussed the subject, whilst the information is discussed in detail in Chapter 11.

One of the earliest 'modern' considerations of the effect sea level change may have had on past human activity and settlement was published in 1975 (Willcox 1975); the opening statement identifying that the Roman Thames was '*perhaps as much as 4m below its present high tide level,*' based on work at Custom House (Tatton-Brown 1974, 13 on Figure 4). Willcox's paper took into account issues such as compaction, erosion and tectonic movement within the London syncline. As well as producing tentative cross-sections of the Thames plotting approximate river levels (based on archaeological and geological evidence), he also produced a graph for the quays then excavated, showing a continued upward trend from the Roman to modern period (Figure 13). Willcox did identify the various problems associated with extrapolating river levels from the quays, although it is debatable whether compaction should be included as the quays tend to be made of oak founded on gravel. The conclusions are cautious, but the paper is a valuable early piece of work attempting to reconstruct changing river levels on the basis of archaeological structures.

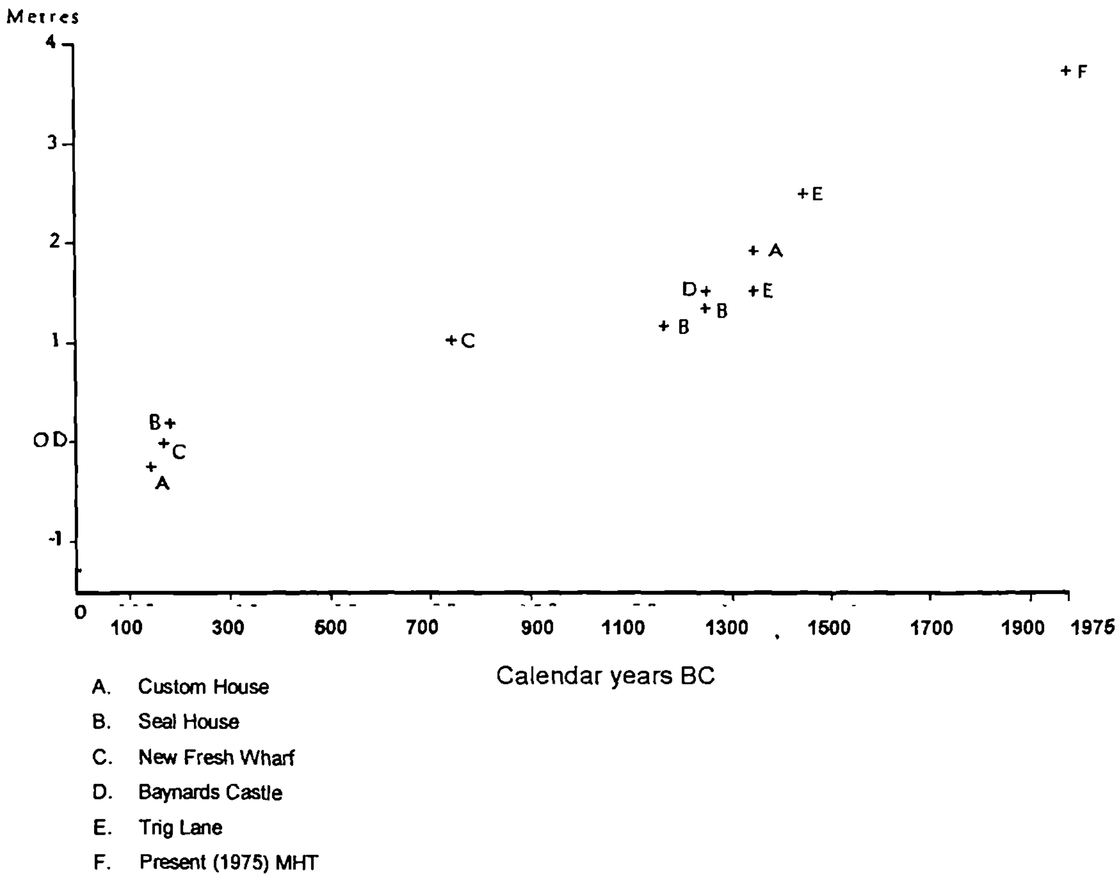



Figure 13. River level change graph, from Willcox (1975)

Graham (1978) identified waterlain clay deposits in Southwark and Lambeth (14 on Figure 4) with post-Glacial marine transgressions flooding the Thames valley. He also attributed the formation of the sand eyots to post-Glacial decreases in river energy levels, subsequently remodeled within an environment of meandering channels, and concluded that central London achieved its major topographic attributes prior to significant increases in relative river levels. Recent work on the Jubilee Line Extension (Sidell et al. 2000) indicates that this was not the case and that at least some of the sand eyots were still forming in the Neolithic. Graham concludes that settlement is not yet indicated in this early period; nevertheless, the area had high potential for resource exploitation. This has subsequently been confirmed (Sidell et al. 2002). He identifies a large-scale inundation in the later prehistoric period, indicated by gravel high being totally sealed and also the partial covering of the three main eyots with waterlain deposits. He dates the inundation on stratigraphic relationships; sealing Late Iron Age and preceding immediately pre-

Roman deposits. A drop in RRL followed this. First and 2nd century revetment levels were recorded and used to indicate likely maximum river levels. Heights of between 0.0m and 1.0m OD were calculated, with the likely mean being between 0.5 and 1.0m OD for this period.

Southwark was readdressed in 1988 (Tyers 1988; Yule 1988). Tyers uses the Devoy model and considers the evidence for 'Tilbury IV' peat in Southwark. A series of sites where peat units were identified interdigitating with alluvial clay-silts are described. The peat units were radiocarbon dated and are generally later Bronze Age. Altitudinally, the sites are also broadly comparable, although there is some question of erosion. Pollen analysis was carried out on two of the sites and indicates fen/carr woodland, but detailed comparison is not made with Devoy's pollen spectra. Nevertheless, the Southwark sediments are identified and described as 'Tilbury IV' although it is stressed that the processes that lead to peat formation in this area may not be those controlling formation downstream at Tilbury itself. This is perhaps understated, as Southwark is twenty miles upstream of Tilbury, and therefore more likely to be heavily influenced by the freshwater river. Yule (1988) examined the local topography in the 1st century AD, specifically considering changes in course around the Southwark eyots and also the rising water levels. Tyers suggested that the topographic features in the area had stabilized by the 1st millennium cal BC, and that the river level had risen to *c.* 1.3m OD by AD 50 on the basis of primary Roman settlement found directly overlying waterlain deposits of this height.

The most recently published examples of archaeological stratigraphy from Southwark (Brigham et al. 1995; Watson et al. 2001) use several new sites and support the models previously proposed by Milne (1985) and Brigham (1990, see below). Brigham et al. (1995), discuss the Courage Brewery warehouse (15 on Figure 4), constructed in AD 152-3 previously within the intertidal zone. The building was located behind a revetment preserved to 1.0m OD; later decaying to 0.5m OD and flooded on several occasions. Watson et al. (2001) summarize the information from several sites, including Borough High Street (16 on Figure 4) and also indicate the presence of occupation below the calculated MHW levels in the 1st century AD, and cite evidence for embanking (Watson et al. 2001, 26) to a height of 1.75m OD. The expansion of the settlement onto lower lying land is used as further evidence to support the model of reduced river levels during the remainder of the Roman period.

On the north bank, research into medieval river levels was undertaken in the 1980's (Milne and Milne 1982), using levels of structures, particularly the waterfront at Trig Lane (17 on Figure 4 and see Figure 14). Milne then researched the Roman north bank (Bateman and Milne 1983; Milne 1985), again using the relative altitudes of quays and revetments. Diatom evidence was combined with stratigraphic data, reaching the conclusion that tidal influence was present in this period at least as far upstream as Pudding Lane (18 on Figure 4). The river is not thought to have risen to above 2.0m OD in the 1st century, with an estimated MHW of between 1.0 and 1.5m OD, which accords roughly with the data suggested for Southwark by Graham (1978). Estimations of relative salinity were made on the basis of diatom assemblages from the 1st and 14th centuries, and it was concluded that the river was more saline in the City in the medieval period than the Roman, and that therefore the location of the tidal head is more likely to have been closer to the City in the Roman period. The paper calculated river levels for Roman, medieval and 1983, indicating a significant increase in tidal range with a practically immobile position for mean tide level.

Several subsequent papers addressed sea level change mainly from archaeological evidence recovered on the north back of the river, although data from Southwark were also cited. The papers by Yule and Tyers had (and indeed still have) a profound effect on the archaeological community working in Southwark. Waddelove and Waddelove (1990) addressed the question of the height of HAT by applying formulae to known heights of structures designed to be above water level, such as quays and revetments. By deducting the extrapolated clearance (*c.* 0.5m) from the known height of the top of such structures, HAT was inferred. A rise in RRL of 4.1m in the last 2000 years (attributed to RSL change) was predicted from the height of the pre-Flavian occupation levels. There are obvious issues with this, such as the validity of the measurement given for clearance - it is possible that the quays flooded entirely on occasion, although this seems unlikely, given the need for a functioning waterfront. However, other authors (Steedman et al. 1992) have attributed the working surfaces of the quays to HAT, which could negate the calculations of Waddelove and Waddelove (1990).

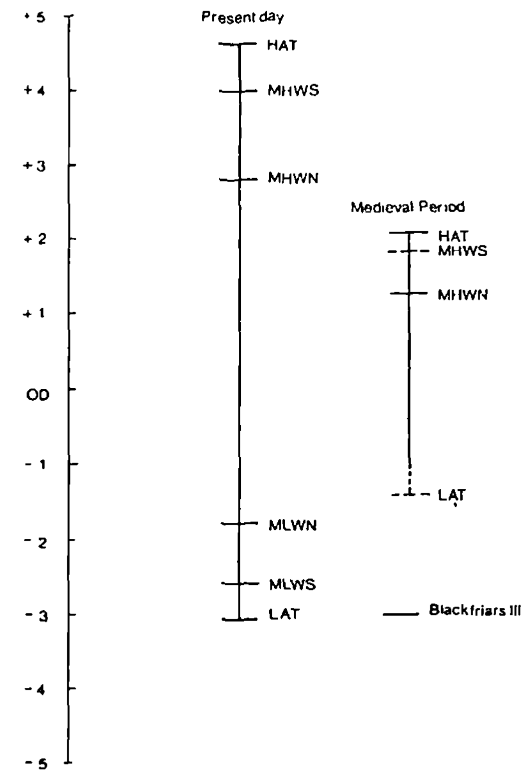



Figure 14. Relative river level graph from Trig Lane, from Milne and Milne (1982, 61, figure 43)

A second paper (Brigham 1990) discusses the Late Roman waterfront, and uses analysis of quays and wharves to suggest a drop in RSL of approximately 1.5m during the Roman period, supported by biological data. Brigham identifies continual waterfront rebuilding, necessary for it to continue functioning, convincingly demonstrated at Regis House since then (Brigham et al. 1996, 20 on Figure 4). In view of the precarious 3rd century economy (Marsden and West 1992), this is significant information. The more recent work at Regis House (Brigham et al. 1996, 20 on Figure 4), and Queenhithe (Ayre et al. 1996; Wilkinson 1998, 19 on Figure 4) confirms these suggestions. Evidence from sites at both Queenhithe (Sidell 2001; Watson et al. 2001, 27) and Thorney Island, (Thomas et al. forthcoming) indicate that river levels increased again from approximately AD 1181. This would appear to be partly a result of the construction of the Colechurch stone version of London Bridge (21 on Figure 4), with the wide stone piers causing an upstream damming effect (Watson et al. 2001, 155). These piers effectively halved the width of the river at that point (see Figure 15). It is perhaps relevant to note that the 1832 rebuild of London Bridge had the effect of increasing the upstream tidal range by 25% (Akeroyd 1972). This is discussed in more detail in Chapter 11.

## Summary

This section has discussed the ways in which archaeologists have reconstructed the Thames river levels. There are large constraints upon this work; most obviously, archaeological features need to be present in a situation directly associated with the river. This tends to rule out all but the urban waterfront of the Roman and subsequent periods, only a kilometre of study area. Also, archaeologists are less scientifically rigorous than earth scientists in connection with aspects such as the examination of salinity. Nevertheless, there are obvious advantages in examining river levels in this manner. The resolution obtained can be much finer than that found within the earth science literature, due to the nature of archaeological datasets.

The majority of the London sequence is dated by dendrochronology, with an error usually of a year. Dates of less resolution than this are generally discarded from the analysis. Artefact dating has also been used, particularly for the occupation surfaces in Southwark, however, artefact typologies for these periods are extremely well dated and the resolution is usually at about 30 years. Furthermore, there are few issues of compaction as the waterfront structures are usually of green oak founded on gravel. The overburden can be substantial, but gravel does not compress. The Southwark islands are of sand over gravel, and again, do not compress significantly in comparison to the clays and peats used in the earth science models from the downstream sites. Another issue is that of calculating reference water levels; habitually one of the more difficult issues in RSL analysis. This is done via structural analysis, for instance, the identification of MHWNT by examining the location of where timbers rot and were repaired. This level is very obvious on the modern wooden waterfront structures in the Thames. Other levels have been calculated by logical inference, i.e. MLWNT is thought to be below the point where access would have been required to construct the waterfronts but above buried hulks. Although there are likely to be divergences from the true picture, the reasoning is logical and likely to have smaller intrinsic errors than those in the earth science models.

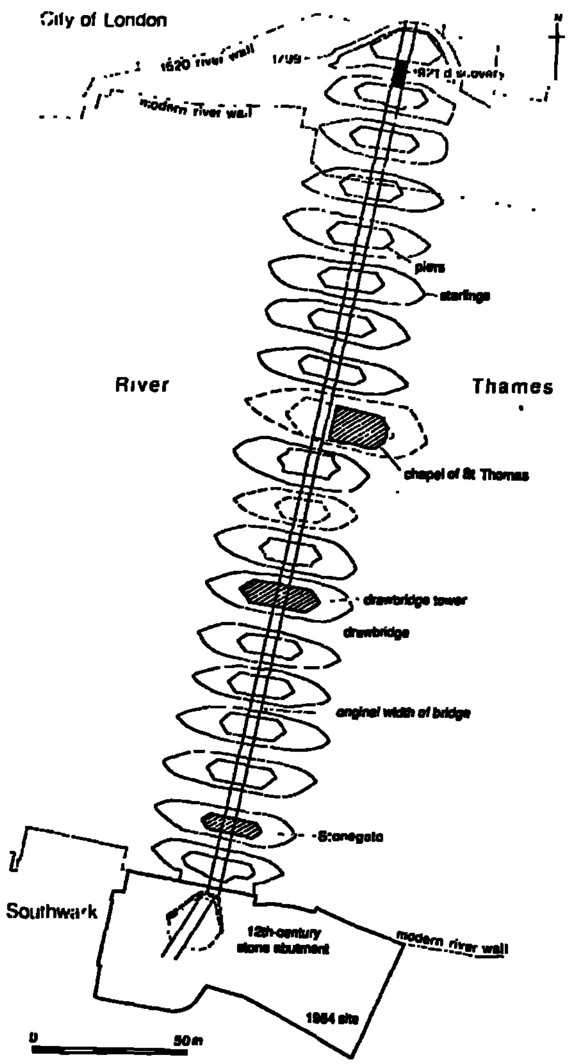



Figure 15. Medieval London Bridge, from Watson et al. (2001, 85, figure 52)

## 2.5 Geological and archaeological background to Greater London

### Introduction

This section is intended as a guide to the current state of knowledge regarding the geology and archaeology of Greater London from the Lower Palaeolithic to the post-medieval period. It is included in order to put the research undertaken for this thesis into a broad topographic and cultural context. The geological background to the region has been studied in detail and therefore is only summarized here. The standard works of geology that have been drawn upon include the current memoir for London (Whittaker 1889) and the current British Geological Survey (BGS) guide to London and the Thames Valley (Sumbler et al. 1996). Other key works include the examinations of the terrace sequences (Gibbard 1985; Bridgland 1994; Gibbard 1994; Bridgland 1995; Gibbard 1995).

With reference to the archaeology, this section should be seen as a general, but by no means exhaustive statement on the development of human society within the London area. London is the most intensively studied archaeological 'site' in Britain and this, in combination with the richness and extent of the archaeological record, has led to a series of publications, both technical and popular. Many have been drawn upon for this section, but primarily '*The Archaeology of Greater London*' (MoLAS 2000), which stands as a marker for knowledge up to the end of 1998. Other, more specific, volumes have been used, as well as personal knowledge.

### Geology

#### *Solid geology*

The London region lies within the London Basin, bounded to the north and north-west by the Chalk of the Chiltern Hills, the Berkshire Downs to the west and the North Downs to the south. On the east, the region is bounded by the North Sea into which the River Thames drains. The Chalk Group (which dates to the Upper Cretaceous series) underlies the entire basin but only rises as hills in these marginal areas mentioned above. Although older sequences are present below the Chalk, none of the deposits are as consistently found as the Chalk (Sumbler 1996, table 1, x). These include the Lower

Cretaceous Gault and Upper Greensand Formations and the Upper Jurassic Portland and Purbeck Formations.

The Chalk is overlain by Palaeogene deposits of the Thames Group, initially Thanet Sands that outcrop around the borders of the Thames basin, but also in other locations such as Greenwich and Sutton (1 and 2 on Figure 16). Subsequent Palaeogene deposits include the marine and estuarine sands of the Lambeth Group (the Reading, Woolwich and Upner Formations). These groups are overlain by the earliest Eocene deposit, the London Clay; a marine mudstone which outcrops in many of the tributary valleys and is present in swathes across South London, for instance in Kingston and Plumstead (3 and 4 on Figure 16). The Claygate Member and the sands of the Bagshot Formation cap the London Clay in these areas of South London. This in turn is more widely overlain by the mid Eocene marine clay, sand and gravel of the Bracklesham and Barton Beds.

### *Drift Geology*

The drift geology of the region is significantly more complex than the solid; a result of the activities of the River Thames since it entered the current Thames Valley during Oxygen Isotope Stage 12 (OIS 12, the Anglian). Subsequently, a series of river terraces (predominantly sand and gravel) have formed and these have been analysed in detail (Gibbard 1985; Bridgland 1994; Gibbard 1994; Bridgland 1995; Gibbard 1995). As yet, these two authors are not in complete agreement about the exact sequence. Additionally, the terrace nomenclature is split between the Upper, Middle and Lower Thames, all of which contributes to the complexity of studying and summarizing the sequence. (The Upper Thames is well upstream of this current study area and is not discussed here). It is a remarkably complete Middle-Late Pleistocene sequence and is vital for an understanding of the rivers history, valley geomorphology and consequently the archaeology of the region (see Figure 17 and Table 9 below).

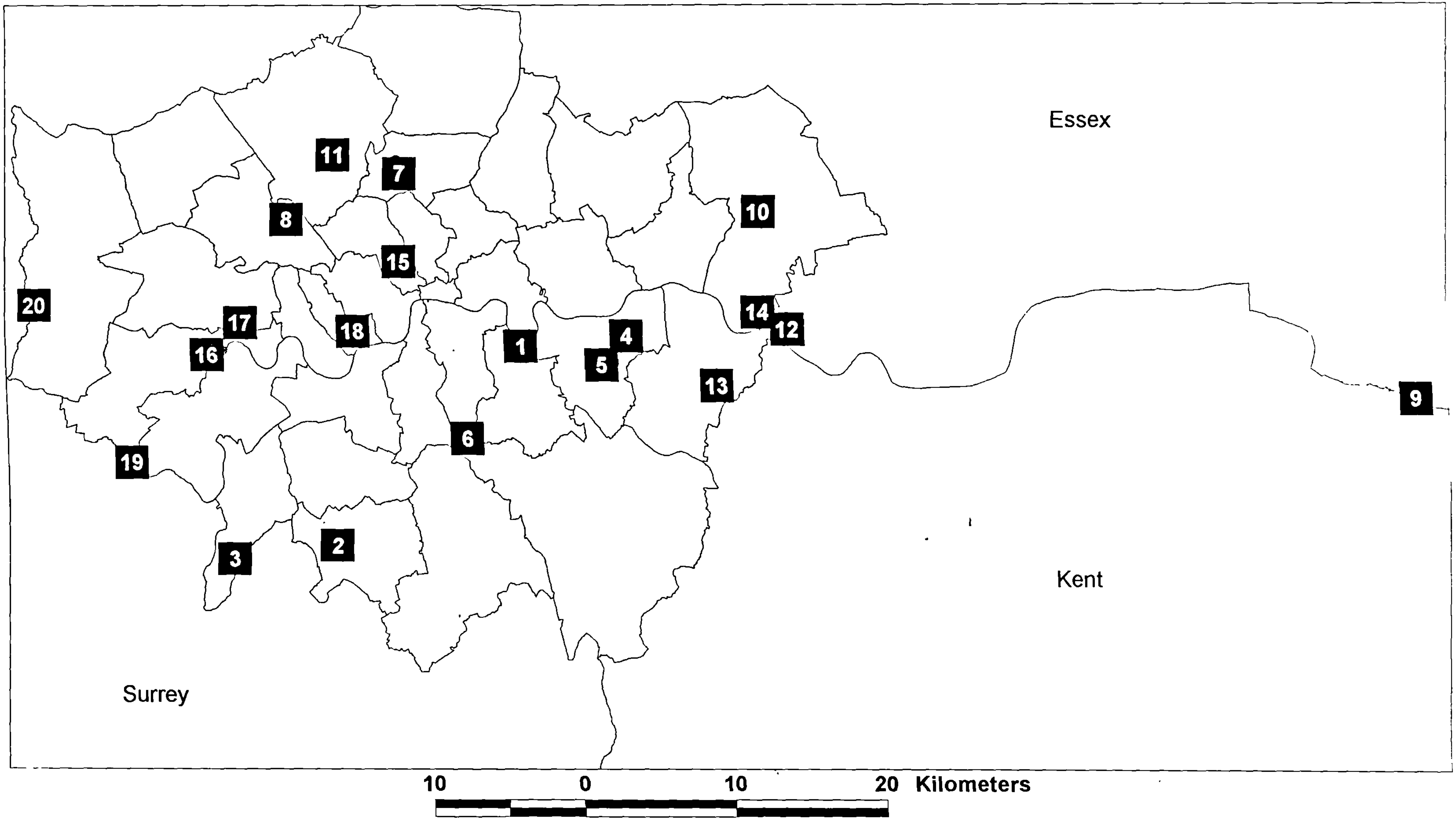



Figure 19. Location map of sites mentioned in discussion of geology

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Greenwich | 3820 | 7780 |
| 2 | Sutton | 2550 | 6450 |
| 3 | Kingston | 1913 | 6363 |
| 4 | Plumstead | 4450 | 7800 |
| 5 | Shooters Hill | 4400 | 7650 |
| 6 | Crystal Palace | 3450 | 7100 |
| 7 | Alexandra Palace | 2950 | 9000 |
| 8 | Dollis Hill | 2250 | 8600 |
| 9 | Swanscombe | 9700 | 7440 |
| 10 | Hornchurch | 5400 | 8700 |
| 11 | Finchley | 2550 | 9100 |
| 12 | Purfleet | 5500 | 7850 |
| 13 | Crayford | 5101 | 7507 |
| 14 | Aveley | 5450 | 7950 |
| 15 | Trafalgar Square | 3000 | 8350 |
| 16 | Brentford | 1800 | 7725 |
| 17 | Gunnersbury | 1900 | 7900 |
| 18 | South Kensington | 2700 | 7900 |
| 19 | Kempton Park | 1200 | 7000 |
| 20 | Yiewsley | 0550 | 8050 |

Table 8. Sites shown on Figure 16

Pre-OIS 12 drift deposits are only found in a few areas of London; these include the so-called Plateau Gravel (Whittaker 1889, 296) or High Level Terraces preserved as relict landforms in areas of London such as Shooters Hill, Crystal Palace, Alexandra Palace, Dollis Hill (5-8 on Figure 16) and Plumstead Common. OIS 12 deposits include the Black Park Terrace in the Middle Thames (Orsett Heath in the Lower Thames). Also, at Swanscombe (on the border with Kent and London, 9 on Figure 16) Stage 12 gravels have been recovered. Additional deposits which accreted in OIS 12 include the Hornchurch Till in north and north-east London, found, for instance at Hornchurch and Finchley (10 and 11 on Figure 16). Stage 11 is slightly more complicated in that both Gibbard and Bridgland agree that there are no OIS 11 deposits in the Middle Thames, but some in the Lower Thames, represented by the Swanscombe sequence. This is published in some detail (Conway et al. 1996; Wymer 1999, 77; Ashton et al. 1995). Put simply, the deposits consist the Upper Gravel with Lower and Upper loams, thought to derive from overbank flood events. The site is perhaps best known for the famous skull found in these deposits (McNabb 1996) and the faunal group, which is now the type fauna for this stage (Wymer 1999, 77).

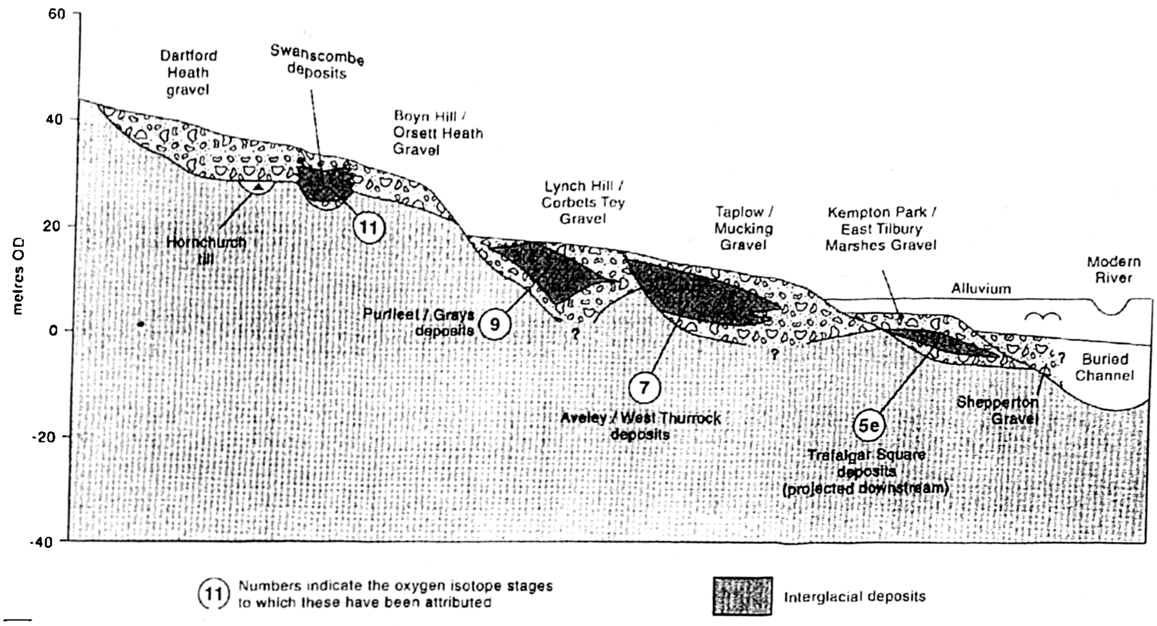



Figure 17. The Lower Thames terraces, Anglian to Holocene, from Bridgland (1995)

On reaching OIS 10, the position becomes even more complex; there is significant dispute on the Thames sequence between Gibbard and Bridgland and indeed dispute on the timing and nomenclature of the period and geological sequences within the wider discipline. It is perhaps logical to follow the European trend adopted by Bridgland (exemplified in his 1994 work) and refer to stages 10-6 as the Saalian Complex, or indeed by stage number alone. Bridgland's description of the terrace sequence indicates that the Boyn Hill Terrace was the earliest to form in this period, found mainly in north and central London within the Middle Thames Valley. It is known as the Orsett Heath Terrace downstream and occurs extensively in Essex and northeast London and is thought to derive from an initial cold stage (OIS 10). The Lynch Hill/Corbetts Tey terraces in the Middle and Lower Thames respectively cut through the Boyn Hill Terrace. Finer grained deposits from OIS 9 (the Purfleet Interglacial) are rare but known from sites such as Purfleet (12 on Figure 16), embedded within the Corbetts Tey Gravel. Further Lynch Hill/Corbetts Tey gravels formed in the subsequent cold stage (OIS 8), as did the next terrace; the basal Taplow/Mucking gravels. These are found prolifically over central and east London.

Stage 7 (the Aveley Interglacial) is represented by fine-grained deposits, including probable palaeosols, mainly in East London, including Crayford and Aveley (13 and 14 on Figure 16), the former particularly noted for the Levalloisian tools recovered from the sediments. Deposition in the subsequent cold stage (OIS 6) was in the form of the upper parts of the Taplow/Mucking gravels and initial deposition of the subsequent terrace, the Kempton Park. This is found in the Middle Thames only, extensively in central and west London, north of the Thames. Gibbard also cites the Spring Garden Gravel as dating to this period (Gibbard 1995) for instance, in Trafalgar Square (15 on Figure 16).

| OIS | Middle Thames | Lower Thames |
|---|---|---|
| 1 | Staines alluvial sequence | Tilbury sequence |
| 2 | Shepperton Gravel | Shepperton Gravel |
| 5d-2 | Langley Silt Complex<br>Kempton Park Gravel<br>Reading Town Gravel | East Tilbury Marshes Upper Gravel |
| 5e | Trafalgar Square sequence | Trafalgar Square sequence |
| 6 | Spring Gardens Gravel<br>Kempton Park Gravel<br>Taplow Gravel | East Tilbury Marshes Lower Gravel<br>Mucking Upper Gravel |
| 7 | | Aveley sequence |
| 8 | Lynch Hill Gravel | Mucking Lower Gravel<br>Corbetts Tey Upper Gravel |
| 9 | | Purfleet sequence |
| 10 | Lynch Hill Gravel<br>Boyn Hill Gravel | Corbetts Tey Lower Gravel<br>Orsett Heath Upper Gravel |
| 11 | | Swanscombe sequence |
| 12 | Black Park Gravel<br>Middle Thames Gravel Formation | Orsett Heath Lower Gravel |

Table 9. Summary of the Thames terrace nomenclature modified after Bridgland (1995) and Gibbard (1995)

The OIS 5c (the Ipswichian Interglacial) deposits have been found in isolated areas, most notably the sands and organic silts at Trafalgar Square (Franks 1960) and the sands in Brentford and Gunnersbury (16 and 17 on Figure 16) in West London. There are no records in the downstream reaches of the region. The Devensian phase of gravel accretion (OIS 5d - OIS 2) succeeded the Ipswichian sediments; this is the upper Kempton Park Terrace and the East Tilbury Marsh Gravel downstream. Some fine-grained sediment is present within these gravels and thought to equate to more temperate periods; these have been found in South Kensington (Coope et al. in press, 18 on Figure 16) and Kempton Park (Gibbard and Hall 1982, 19 on Figure 16). During this glacial stage, further downcutting by the river lead to the creation of what has been called the buried channel, which cuts significantly below the modern river. This has been filled with the lowest of the gravels, the Shepperton Terrace. Several areas of the London drift also contain loessic deposits (known locally as brickearth). It is variable in character, some being entirely windblown, but some deposits known as the Langley Silt Complex (Gibbard 1994, 94) are derived from a combination of aeolian and colluvial processes. There is also great variety in the dates of these deposits; those located in east London and parts of west London appear to date to around the time of the Devensian Late Glacial maximum, *c.* 18,000 BP, whereas in locations such as Yiewsley (20 on Figure 16), a date of 140,000 years BP has been recorded (Gibbard 1994, 97). These gravels and brickearths form the total of the drift deposits in the London region.

Holocene deposits (OIS 1) are locally variable and have not been examined in the same level of detail that exists for the Pleistocene sequence. Very few models exist; one such is that of Devoy (1979, 1980) mentioned above (see Figure 18). More recent work (Bates 1999; Long et al. 2000; Sidell et al. 2000; Wilkinson et al. 2000) has concentrated upon detailed examination of small areas or looked more broadly at floodplain development. This absence of a detailed model covering the estuary is exemplified by the regional geological summary (Sumbler et al. 1996), where the model of Devoy is used to summarize Holocene deposits within the estuary (see Figure 18).

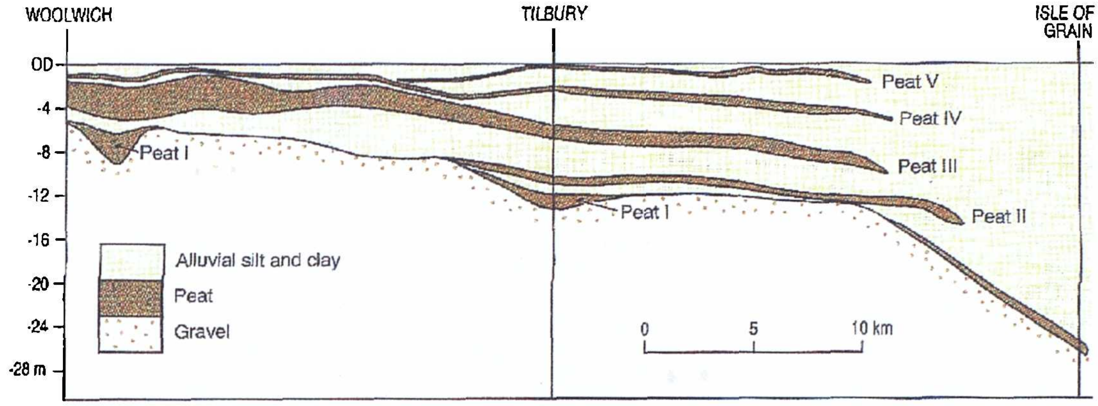



Figure 18. Summary Holocene sequence from Sumbler et al. (1996)

## Archaeology

### *Palaeolithic (c. 450, 000 – 9500 cal BC)*

Palaeolithic evidence in the London region is extensive in comparison with other parts of the British Isles and appears to be associated with the Thames Valley, which acted as a focus for hominid and human activity, perhaps because it acted as a migratory routeway. As with the majority of Palaeolithic sites in Britain, much of the evidence takes the form of flint tools, predominantly bifaces. These are, on the whole, derived and have usually been recovered from the gravel terraces (see above). These sequences have been described in exhaustive detail and it is enough to state here that these terraces contain the remnants of previous surfaces upon which lithics were discarded.

Antiquarians recovered many of the artefacts currently held in museum collections in the 19th century when gravel extraction was undertaken by hand and the Thames was extensively dredged. This led to the recovery of large amounts of lithics, because they were easily observable, unlike modern gravel extraction techniques that are highly mechanized. The artefacts were easily sold to collectors such as Layton and Worthington Smith (Whipp and Blackmore 1978). However, the artefacts were generally out of context, with the very rare exceptions such as the 'nests' of flints recovered from Wansunt Pit (Chandler and Leach 1912; White et al. 1995, 1 on Figure 19). Approximate locations could occasionally be ascribed and many of the early researchers in the field, such as Worthington Smith, Spurrell, Chandler, Leach and Whittaker attempted to reconstruct the horizons from which material derived.

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Wansunt Pit | 1500 | 7390 |
| 2 | Stoke Newington | 3350 | 7865 |
| 3 | Three Ways Wharf | 0525 | 8458 |
| 4 | Nightingale Estate | 3390 | 7862 |
| 5 | Erith Spine Road | 5060 | 7880 |
| 6 | Swanscombe | 9700 | 7440 |
| 7 | World Cargo, Heathrow | 0727 | 7450 |
| 8 | Church Lammas | 0275 | 8725 |
| 9 | B&Q, Old Kent Road | 3430 | 7789 |
| 10 | West Heath Hampstead | 2567 | 8670 |

Table 10. Sites shown on Figure 19

Dredging produced similar results; many spectacular finds were recovered in this manner, not solely Palaeolithic tools, but the tremendous metalwork such as the Battersea shield and the collections of Bronze Age spearheads held in the Museum of London and the British Museum (Cotton 1999). Again, although dredging could provide a general location, if the finders actually recorded it, material within the river was very unlikely to be in primary context. Furthermore, in addition to the academics trying to study material, there was a band of collectors and dealers vying to obtain artefacts for profit and display with the result that many artefacts were not studied at all. Therefore, although some information may be gained from derived material, the data is of necessity more of a typological nature, relating to technology and developing tool kits rather than actual human life at a given location.

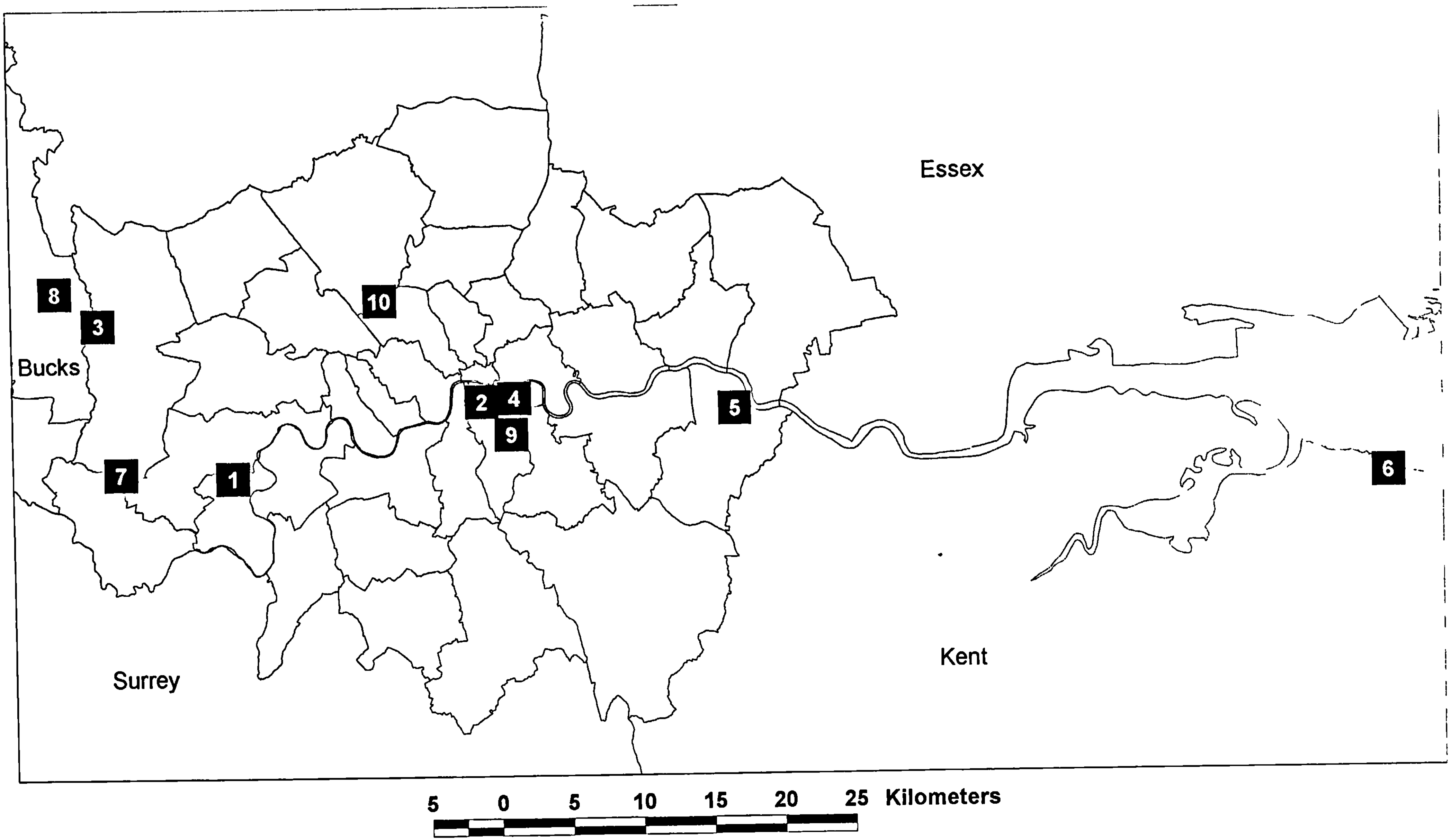



Figure 19. Location map of Palaeolithic and Mesolithic sites

The site of Wansunt Pit, Crayford is probably the most significant Palaeolithic site in the region, if Swanscombe (6 on Figure 19) is excluded from London (often debated when considering the Palaeolithic record, where modern political boundaries have no relevance). Two main units are present, the Dartford Heath Gravel and the Wansunt Loam (Bridgland 1994, 186); both of which are currently thought to date to OIS 11. The Dartford Heath Gravel has yielded little in the way of artefacts and those present appear to be derived. Faunal remains have been found within it, including *Dicerorhinus* sp. (rhinoceros), *Palaeoloxodon antiquus* (straight-tusked elephant) and Cervidae (deer). This material, although important, is of less interest and significance than the Wansunt Loam where the artefacts are present in much greater quantities and most significantly, are *in situ*. The Loam represents overbank flooding from a channel cutting through the southern part of the modern quarry. The known artefacts (many are likely to have been lost to collectors earlier this century) include many 'mint' bifaces (mainly ovate with some cordate), flakes, cores and scrapers but also have included several concentrations of refitting flakes (Bridgland 1994). The lithics are described in several publications (Smith and Dewey 1915; Chandler 1916; Wymer 1999, 73). The three-metre long section that was cleaned in 1995 yielded ten lithics; six flakes, two cores and two bifaces and all but one were considered to be in mint condition (White et al. 1995, see Figure 20 below). The most recent excavation in 2000 (as yet unpublished) yielded a further small group of artefacts.

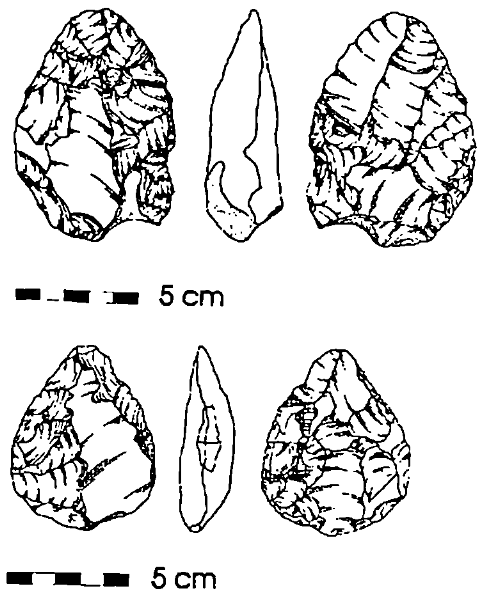



Figure 20. Flint tools from Wansunt Pit, from White et al. (1995)

The other main area of Lower Palaeolithic interest in London is Stoke Newington (2 in Figure 19), associated with the work of Worthington Smith (1894), who identified a 'working floor' upon which *in situ* lithics were scattered, before becoming sealed by brickearths. The lithics include a series of small bifaces and scrapers of pre-Levalloisian type. Recent work has suggested a small degree of movement from the nearby Stoke Newington sands (MoLAS 2000, 35); however, refits have been made and so the integrity of the group is probably still high.

The site at Three Ways Wharf, Uxbridge (3 on Figure 19) is the only good example of an *in situ* Upper Palaeolithic site in London (Lewis 1991). A small group from the World Cargo site at Heathrow (7 on Figure 19) is the only other *in situ* group and indeed there are very few *ex situ* finds in addition. Three Ways Wharf is located on the edge of the River Colne and the 'long blade' flint scatter (see Figure 21) is located within silts that have been deposited by the river, associated with a series of bones. These include *Rangifer tarandus* (reindeer) and *Cervus elaphus* (red deer), a number of which have cut-marks indicating local butchery. Another site like this is located farther downstream, just outside the region, at Church Lammas, Staines (8 on Figure 19).

Largest = *c.* 100mm in length

**Figure 21. Flint tools from Three Ways Wharf, from Merriman (1990)**

It is rare that any organics are recovered with the stone tools, but sharpened birch stakes are known from Stoke Newington (Smith 1894). Wymer has recently argued that beavers, rather than people, may have modified these (Wymer 1999, 63). Recent fieldwork recovered organic-rich deposits from the nearby Nightingale Estate (Hackney) (Green and Branch 2000, 4 on Figure 19), which contained timber, plant macrofossils, molluscs and beetles, indicating a depositional environment of channel marginal sedimentation in a warm climate. This OIS 9 site is thought to be contemporary with the artefacts recovered nearby. Other organic material comes in the form of large mammal bones. These have been collected from a number of the terraces and some of the excavated sites such as Wansunt Pit where *Palaeoloxodon antiquus*, *Cervus elaphus* and *Equus caballus* (wild horse) were recovered. The most famous of these collections is the OIS 5e assemblage from Trafalgar Square (Franks 1960; Stuart 1976, 1982), which includes *Panthera leo* (lion), *Palaeoloxodon antiquus*, *Stephanorhinus hemitoechus* (narrow-nosed rhinoceros) and *Hippopotamus amphibius* (hippo) amongst others. Unfortunately, the apparent absence of humans in Britain in this period renders it of less interest to archaeologists than other Pleistocene stages.

### *The Mesolithic (9500-4000 cal BC)*

The evidence for the Mesolithic period is also relatively ephemeral, befitting the types of material preserved. Again, as with the Palaeolithic period, much evidence is in the form of flint tools, however, more organic material has been recovered. The site of Three Ways Wharf, mentioned above, also contained an Early Mesolithic scatter and is the most significant site of this date in Greater London (Lewis 1991). This scatter shows a change in the fauna from a cold climate group to one dominated by species more indicative of a warmer wooded environment, such as *Cervus elaphus* and *Bos primigenius* (aurochs). The re-fitting and matching of the tools with the bones show that carcass processing was being undertaken here and it may be that this was a home base rather than a hunting site were animals were slaughtered prior to being processed elsewhere.

Another Early Mesolithic site comes from the Old Kent Road (Rogers 1990; Sidell et al. 2002, 9 on Figure 19). It is not as substantial as Uxbridge, but shows a similar home base with a range of activities occurring on the margins of a lake. These activities include hide processing, leather working and the cutting of bone, wood and fibrous plant material. It also seems that flint nodules were cached close to the hearths before being individually selected for knapping (reconstructed in Figure 22). Unfortunately only one bone preserved in the sandy soils of the site; a burnt fragment of a possible *Capreolus capreolus* (roe deer) metapodial and so practically nothing can be said of the economy of the site.

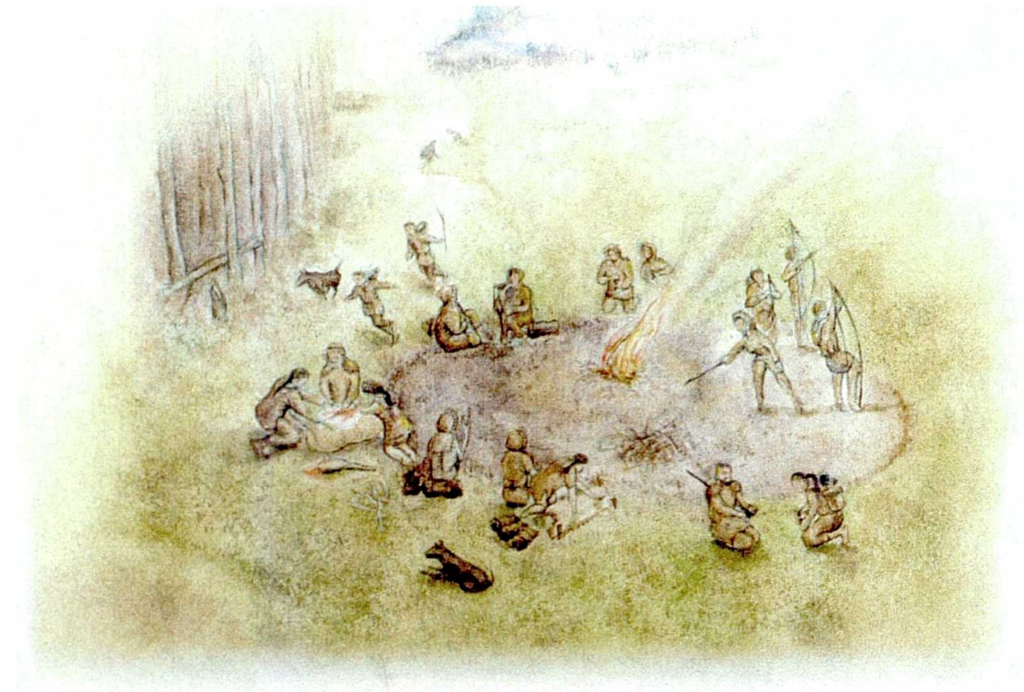


Figure 22. Reconstruction of the B&Q site, by Kikar Singh

A Late Mesolithic site at the Erith Spine Road (Taylor 1996; Bennell 1998, 5 on Figure 19) was only (partially) rescued at the last minute during road construction and so data retrieval was minimal. Nevertheless sufficient information was present to show that a very extensive flint scatter, probably extending over hundreds of metres, was present on what appears to have been the contemporary foreshore. Mesolithic activity is often found in river valleys, but mainly the tributaries of the Thames rather than the Thames itself (Wilkinson et al. in press), therefore this is an unusual and important site. The evidence in the tributaries tends to occur in the form of individual find spots or small scatters. Dryland sites are rare, however, the site at West Heath, Hampstead (Collins and Lorimer 1989, 10 on Figure 19) is a striking example of a site removed from the floodplain and it demonstrates that the contemporary groups did utilise the higher, forested ground as well as concentrating on resources available in the floodplain. A great range of tools were recovered from the scatter at Erith, unfortunately, as with B&Q, the soils did not preserve any bone, but the range of tools indicate a manufacturing site, potentially used over a number of seasons. Importantly, a piece of Grimston-Lye Hill pottery was found; an Early Neolithic type, and its presence at this site may indicate that the timing of cultural change within the conventional nomenclature of 'Neolithic' and 'Mesolithic' may have to be revised.

There are few major sites of Mesolithic date, but this is almost certainly associated with their archaeological 'invisibility'. There may be sites deeply buried either under later stratigraphic accumulations or under waterlain sediment in the floodplain (Merriman 1992). Also, the debris left tends to be ephemeral and often it is only the tools that preserve. Nevertheless, the information gathered to date indicates that a series of mobile groups traversed the area, presumably on a seasonal basis, migrating along the Thames valley and utilizing areas close to water bodies such as the Colne, Lea, Wandle and the Thames itself, as well as establishing camps in the woodlands on the terraces.

### *Later prehistory (4000 cal BC – AD 43)*

This division equates roughly to the Neolithic, Bronze and Iron Ages. Recent work has suggested that these terms are perhaps not as useful as was once thought (Cotton 2000; Bradley 2001), in that the characteristics conventionally ascribed to societies of these dates are not necessarily identified in the archaeological record. This includes fundamental patterns such as the development of settled, agriculturally based groups as well as the introduction of pottery and new technology. Therefore, this section will present a chronological narrative of the patterns of activity actually identified in London.

Traditionally, the Neolithic period is thought to have seen the first appearance of settled groups, farming and ceramic production. These are acknowledged to have overlapped with a continuity of the mobile hunter-forager lifestyle in what has been termed an existence of 'tethered mobility' (Whittle 1997). This continuation of mobile groups appears to be extremely pronounced in London, in that there is very little evidence for early settled farming groups at all within the date ranges traditionally identified with the Neolithic. Previously, this could have been explained by a shortage of evidence or a biased dataset resulting from the nature of archaeological intervention in

London, i.e. the antiquarian interests tending to focus mainly on the Roman core in combination with the random nature of commercial development. However, recent detailed investigative work indicates that this is not the case, and there is a genuine gap in the archaeological record at this period (MoLAS 2000; Wilkinson and Sidell submitted).

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Erith Spine Road | 5060 | 7880 |
| 2 | Kingston | 1913 | 6363 |
| 3 | Rainham | 5280 | 8200 |
| 4 | Runnymede Bridge | 0157 | 7199 |
| 5 | Staines | 0400 | 7150 |
| 6 | Yeoveney Lodge | 0251 | 7255 |
| 7 | Shepperton | 0820 | 6751 |
| 8 | Heathrow | 0560 | 7653 |
| 9 | Stanwell Cursus | 0450 | 7740 |
| 10 | Fort Street Silvertown | 4077 | 8020 |
| 11 | North Woolwich | 4345 | 7985 |
| 12 | Beckton | 4270 | 8200 |
| 13 | Barking | 4380 | 8350 |
| 14 | Dagenham | 4860 | 8330 |
| 15 | Bramcote Grove | 3515 | 7805 |
| 16 | Fennings Wharf | 3281 | 8037 |
| 17 | Phoenix Wharf | 3379 | 7965 |
| 18 | Nine Elms, Vauxhall | 3020 | 7800 |
| 19 | Joan Street | 3160 | 8010 |
| 20 | Hopton Street | 3182 | 8045 |
| 21 | Canada Water | 3550 | 7950 |
| 22 | London Bridge | 3280 | 8030 |
| 23 | Bermondsey Abbey | 3340 | 7933 |
| 24 | Coronation Buildings | 3040 | 7777 |
| 25 | Caesars Camp, Wimbledon | 2240 | 7110 |
| 26 | Uphall Camp | 4383 | 8508 |
| 27 | Hunts Hill Farm | 5660 | 8310 |
| 28 | Stockley Park | 0825 | 8075 |
| 29 | Imperial College Sports Ground | 0810 | 7770 |

Table 11. Sites shown on Figure 23

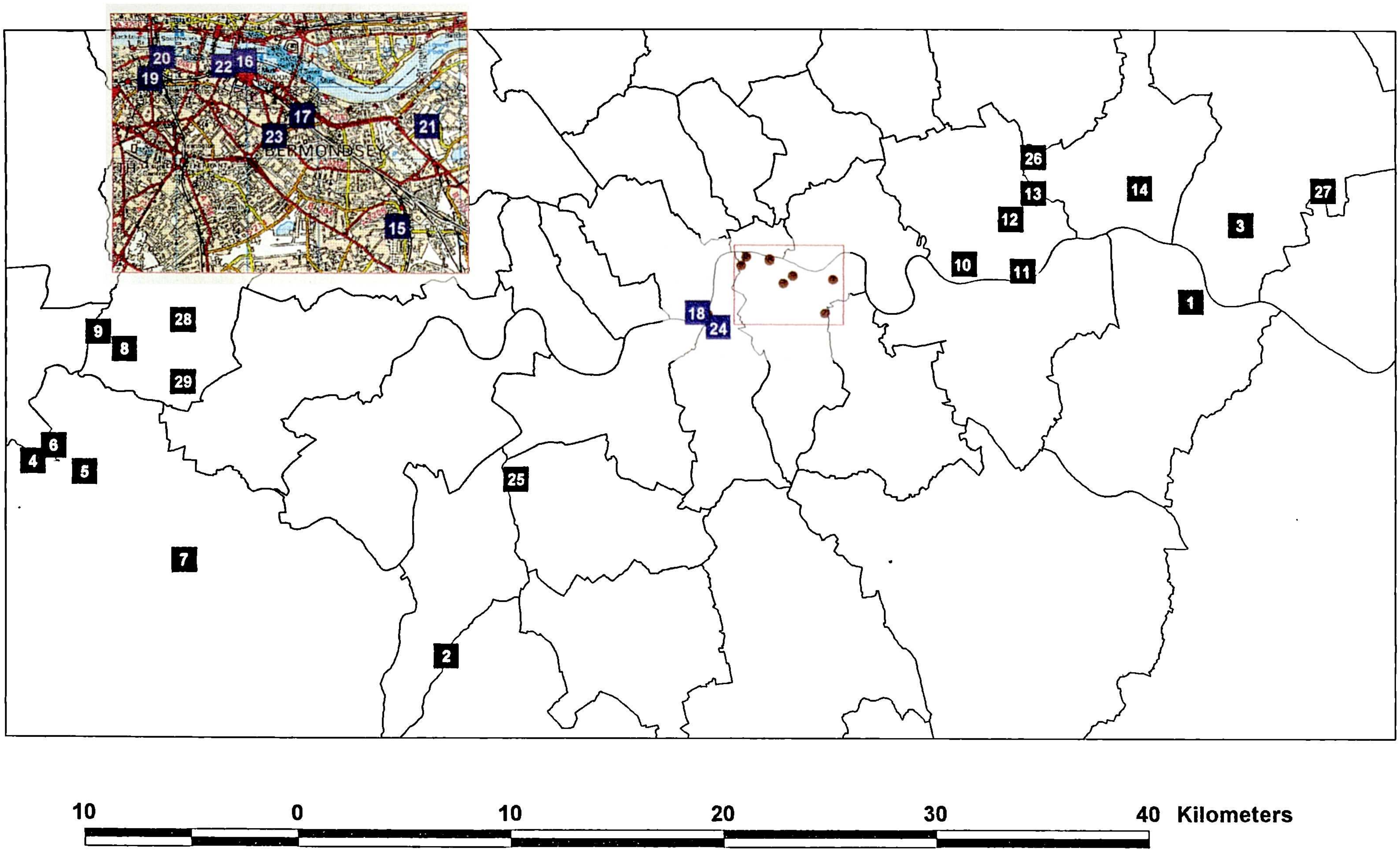


Figure 23. Location map of later prehistoric sites

Much of the dataset is in the form of stray finds; mainly flint axes that have been collected by antiquarians or dredged from the river. These are out of context and are not helpful in analysing the patterns of activity within the region other than simply to indicate that there was some form of occupation. Distribution maps of find spots tend to show clusters of material from the Thames and the gravels of west London. This bears out the idea that the finds come from antiquarian (i.e. gravel pit collection) and river finds. Some early ceramics have been found, but not in association with obvious settlement, i.e. the Grimston-Lye Hill Ware, found at Erith (Bennell 1998, 1 on Figure 23) and some slightly later material from Kingston (Penn et al. 1984, 2 on Figure 23). There is evidence for actual settlement in Rainham (3 on Figure 23) where a group of sites have produced a range of artefact types and several enclosure-like features were recovered, but this is a very rare example and as yet, not fully published (see Greenwood 1982). There is nothing in the Greater London region that can compare with the Early Neolithic evidence from Runnymede Bridge (Needham 1991, 2000, 4 on Figure 23) where a range of structures were found, including a long house, waterfront and many artefacts.

The Early Neolithic in Britain is also known for monumental structures. Again, these are lacking within Greater London, although there are several on the periphery, for instance the Staines ring ditch (5 on Figure 23) and the Yeoveney Lodge causewayed enclosure (Merriman 1990, 6 on Figure 23). In the later Neolithic, from *c.* 3000 cal BC settlement does begin to occur, mainly in west London, on the gravel terraces. In addition to isolated settlements such as Shepperton (7 on Figure 23), Heathrow (8 on Figure 23) and Kingston (Lewis 2000, 68), ritual structures were also constructed, most spectacularly the 4km long Stanwell Cursus (or bank barrow, 9 on Figure 23 and see Figure 24) which now appears to have been sited over earlier Mesolithic sites (Barrett et al. 2000). This forms part of a wider ritual landscape, of which as yet, very little is understood in terms of how it was used, although recent excavations and a more post-processual approach to their interpretation should help resolve this (Andrews et al. 1998).

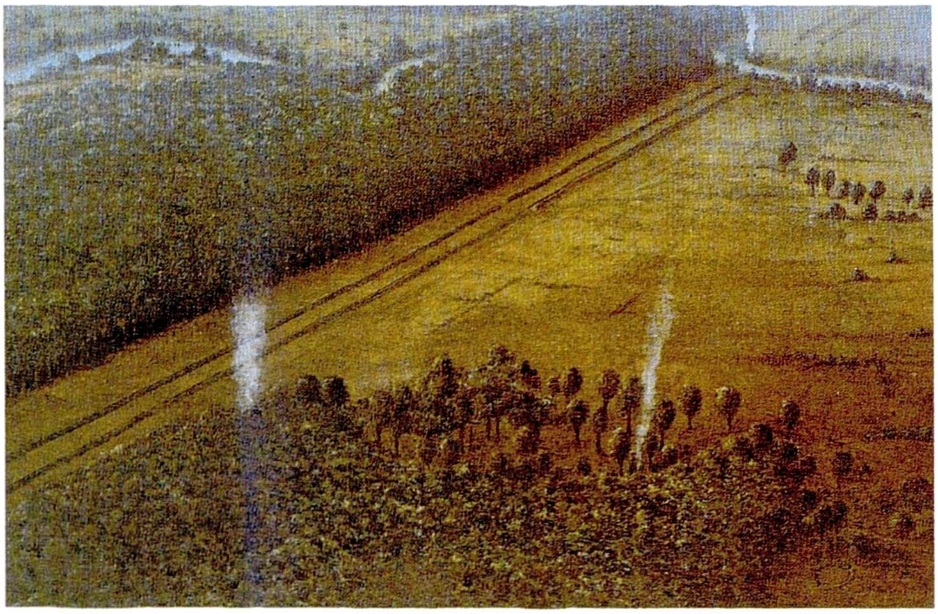


Figure 24. Reconstruction of the Stanwell Cursus, from Merriman (1990)

Some activity of Late Neolithic date has been recovered from the floodplain, such as the trackway found at Fort Street, Silvertown (Meddens 1996; Crockett et al. in press, 10 on Figure 23), and settlement activity in North Woolwich (11 on Figure 23). This indicates the wetland areas were being least traversed and exploited, possibly for seasonal grazing of livestock. Ecologically, there is some evidence for the opening up of the woodlands from approximately 3000 cal BC –one of the 'characteristics' considered to define the Mesolithic/Neolithic transition which certainly occurs later in London than such a model would predict. Traditionally, the elm decline has been seen as the first evidence for deforestation (Scaife 1988), although limited evidence of large-scale fires is known. This event has been identified at several sites across London in the Late Mesolithic pollen record, although it is often absent in organic sequences in the central London floodplain (where the majority of archaeological work has occurred) because these tend to start forming in the Early Neolithic.

The intensity of activity increases from the late third millennium cal BC and into the second. This period sees the development of extensive field systems over west London (Yates 1999), which in some cases made use of existing features of the 'ritual landscape'. West London appears to be the focus for settlement in this period, but in this instance, it seems likely that this has resulted in a bias in the dataset. The evidence for this suggestion lies in the east London floodplain. There are a series of timber trackways (see Figure 25 below), all dated to the middle of the second millennium cal BC along with timber platforms which have been recovered from within the peat beds (Meddens and Beasley 1990; Meddens and Sidell 1995; Meddens 1996). As yet, no settlement has been found, but it seems likely that the gravel terrace just to the north of many of the sites in North Woolwich, Beckton (12 on Figure 23), Barking (13 on Figure 23) and Dagenham (14 on Figure 23) is the logical location for permanent occupation sites exploiting the wetland resources.

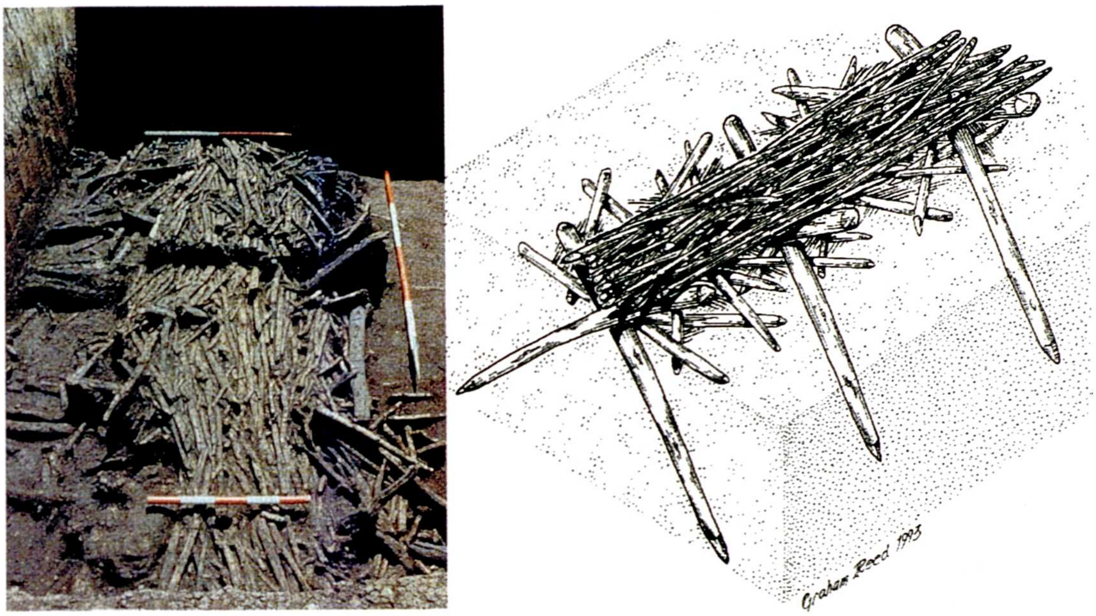


Figure 25. Bronze Age trackway with reconstruction from Beckton 3D, from Meddens (1996)

This pattern is observable in other parts of London; the Erith spine road excavations (Bennell 1998) uncovered a similar hurdle-built timber structure within the Bronze Age peat horizons associated with some artefactual material but no permanent structures. This can also be said of the site at Bramcote Grove, Bermondsey (Thomas and Rackham 1996, 15 on Figure 23). Central London appears is slightly different, however. The evidence from Fennings Wharf (London Bridge, 16 on Figure 23), Phoenix Wharf (Tower Bridge, 17 on Figure 23) and possibly Nine Elms, Vauxhall

(Milne 2002, 18 on Figure 23) indicates a scaled down version of the west London 'ritual landscape' from *c.* 2000-1600 cal BC. And yet, there is some evidence, in the pollen record from Joan Street (Sidell et al. 2000, 73, 19 on Figure 23) and in the form of ardmarks from Hopton Street (20 on Figure 23), both close to Blackfriars Bridge (Ridgeway 1999), for farming overlapping with this period, from approximately 2000 cal BC. This would seem to be an early phase of cultivation, in isolated areas, with another potentially close to Canada Water (21 on Figure 23) on the Rotherhithe peninsula (Sidell et al. 2000, 97). However, the main evidence for cultivation in the central area comes from a group of sites downstream of modern London Bridge (22 on Figure 23) where ardmarks were recovered, cut into the sand island upon which the fields were situated. These appear to date to roughly 1500 cal BC and were probably under the plough for only a few hundred years before they were inundated at approximately 1200 cal BC (or possibly earlier) when estuarine waters reached this location (Sidell 2000, 122). There is no further activity on a large scale in central London; it would seem that subsequent to the incursion of tidal waters, the area was abandoned.

Iron Age activity is even more elusive: this is considered to be a factor of archaeological invisibility and a real absence associated with a significant cultural change from approximately 700 cal BC (Merriman 2000). Furthermore, the limited evidence is poorly published. There are traces of activity in central London, with reasonable sized finds assemblages from Bermondsey Abbey (Steele forthcoming, 23 on Figure 23) and Coronation Buildings (Sidell et al. 2002, 24 on Figure 23). Nevertheless, the evidence for settlement is non-existent and it would seem that central London continued to be largely unsettled from the Late Bronze Age until the Roman conquest. And yet, the central London Thames has produced one of the richest assemblages of contemporary metalwork of any city in Europe (Wait and Cotton 2000, 87). Settlements are known from the gravel terraces of east and west London with small enclosures such as Caesar's Camp, Wimbledon (25 on Figure 23) and then the larger sites, including Uphall Camp (26 on Figure 23) and Hunts Hill Farm (Greenwood 1997, 2001, 27 on Figure 23), which are typical defended settlements. These enclosures tend to have concentrations of huts, granaries, sheds and stock enclosures within them. The Iron Age occupation of west London, in comparison to these east London sites is slightly different - there seems to be less emphasis on defence and more evidence for field systems and stock management with good examples at sites such as Stockley Park, Heathrow (MoLAS 2000, 106, 28 on Figure 23) and Imperial College Sports Ground, Harlington (Wessex Archaeology 1998; Crockett 2002, 29 on Figure 23). This pattern of isolated small settlements and farmsteads appears to have continued until, and in some cases beyond, the Roman invasion of Britain.

### *The Roman period (AD 47-410)*

Roman London; *Londinium*, is thought to have been settled slightly after the Claudian conquest of AD 43 (Grimes 1968; Merrifield 1969; Milne 1995), probably by about AD 47, based on a recent dendrochronology date from 1 Poultry (Rowsome 2000, 17, 1 in Figure 27. The archaeological evidence from *Londinium* is substantial, in part owing to its burial beneath medieval and post-medieval strata and takes the form of walls, buildings, roads, waterfronts, cemeteries and earthworks, for example. There are also a few literary sources that may be used to help build a picture of the city and its history. The town, roughly similar in location to the modern City of London, did not represent a continuity of settlement. No Iron Age settlement is known from the immediate environs, or indeed central London as a whole. A suggestion concerning the reason for this location is that the hills either side of the Walbrook and rising from the Thames (associated with the breaks in slope from the Shepperton to the Taplow Terrace) paralleled the hills of Rome. This is not a practical reason to site *Londinium* here, and the archaeology of Roman Britain demonstrates that the Roman infrastructure was firmly based on practical lines. What seems more likely is that the city was located at approximately the tidal head of the estuary in order to facilitate navigation (Merrifield 1969, 21). The city was destined to be a port and therefore the river would have been of huge significance in the siting of the city. In addition to the settlement on the north bank, Southwark (1 in Figure 26) was also colonized. Previously, Southwark has been identified as a suburb to the city; this view has now been altered and the occupation in Southwark is seen to have been on a par with that of the north bank (MoLAS 2000, 122). In addition to these areas, the hinterland gradually became occupied, with settlements springing up in places such as Brockley Hill (2 in Figure 26), Brentford (3 in Figure 26), Ewell (4 in Figure 26) and Staines (Sheldon and Schaaf 1978, 5 in Figure 26). These, and others, tended to be on the line of the road network that radiated out from *Londinium* and many of them also co-incided with rivers.

They consisted generally of clay and timber buildings, both domestic and industrial associated with concerns such as ceramic manufacture.

*Londinium* developed rapidly with significant amounts of building completed by AD 60, when the Boudican revolt razed the city to the ground. Massive fire horizons of this date have been found across the city and Southwark, indicating that the descriptions recorded by Tacitus (*Annals* XIV) were only too accurate. Nevertheless, rather than abandon the town, the rubble was cleared, or in some cases, such as at 1 Poultry (Rowsome 1998) simply leveled and, tell-like, built upon. The waterfront sequence at Regis House (2 in Figure 27) shows that by AD 63 a new substantial quay and waterfront had been put in place (Brigham et al. 1996); again this may reflect the importance of the waterfront to the city as well as the speed with which the city was rebuilt. It is from this date that the major public buildings appear, continuing in use over several centuries, such as the Guildhall amphitheatre (Bateman 1997, 2000, 3 in Figure 27), the Cripplegate Fort (Grimes 1968, 4 in Figure 27) and the forum-basilica complex (Milne 1992, 5 in Figure 27). Further evidence for public buildings has been found throughout the city with the Huggin Hill bathhouse (6 in Figure 27), and the Walbrook Mithraeum (Shepherd 1998, 7 in Figure 27) in combination with a range of private townhouses (Perring et al. 1991). The city seems to have undergone a decline in the late 2nd/early 3rd century. The exact nature (and cause) of this is unknown, but it is made manifest in the decay of some of the larger buildings and the abandonment of whole *insulae*. This seems to have been reversed in the later 3rd century, when a further building programme occurred

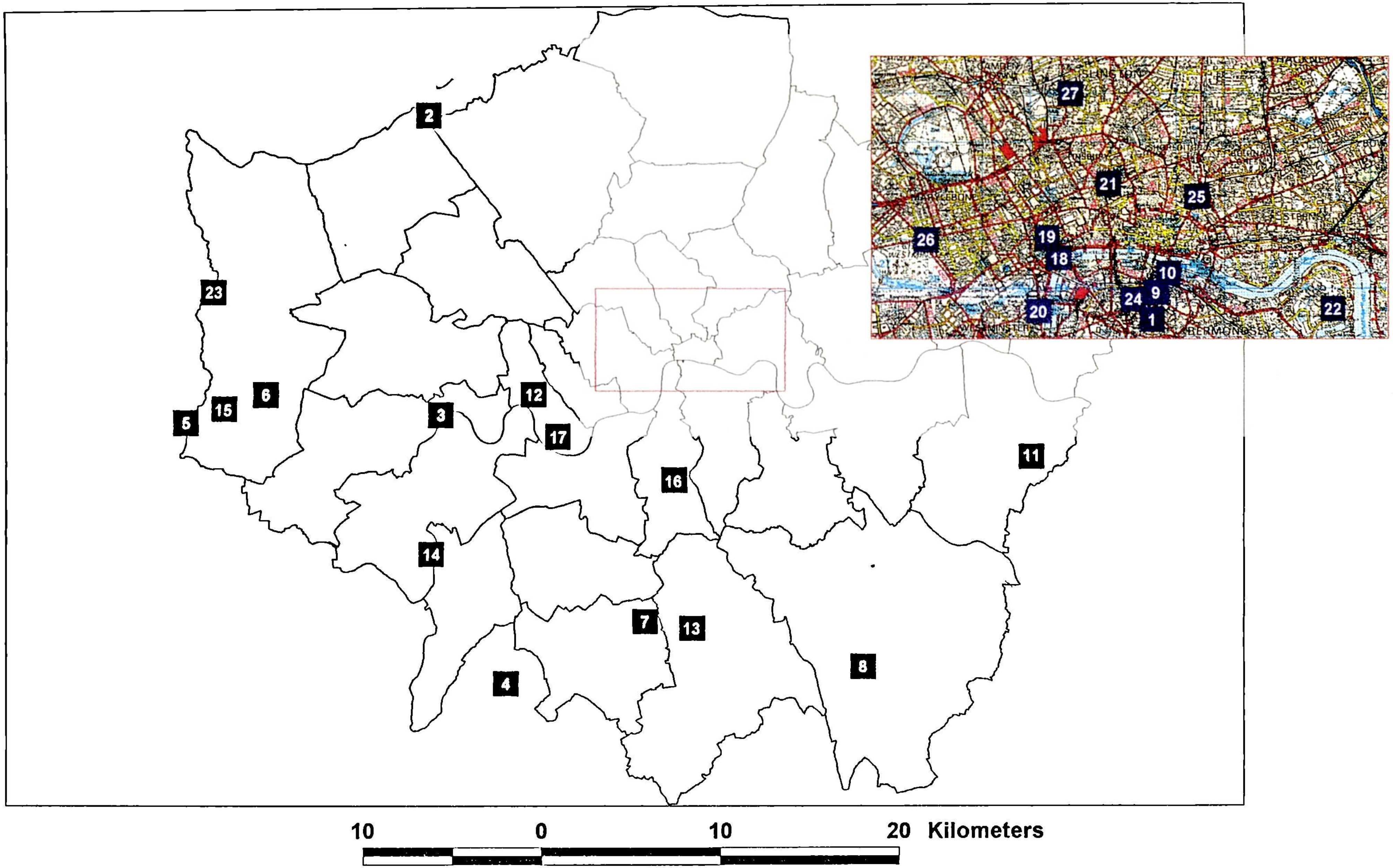



Figure 26. Location map of Roman sites outside the City walls

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Southwark | 3250 | 7950 |
| 2 | Brockley Hill | 1750 | 9400 |
| 3 | Brentford | 1800 | 7725 |
| 4 | Ewell | 2150 | 6250 |
| 5 | Staines | 0400 | 7715 |
| 6 | Wall Garden Farm | 0780 | 7840 |
| 7 | Beddington | 2979 | 6576 |
| 8 | Keston | 4140 | 6320 |
| 9 | Borough High Street | 3255 | 7995 |
| 10 | London Bridge | 3280 | 8030 |
| 11 | Crayford | 5101 | 7507 |
| 12 | Hammersmith | 2330 | 7790 |
| 13 | Croydon | 3200 | 6546 |
| 14 | Kingston | 1778 | 6930 |
| 15 | Harmondsworth | 0560 | 7780 |
| 16 | Tulse Hill | 3100 | 7350 |
| 17 | Fulham | 2430 | 7626 |
| 18 | Strand | 3053 | 8079 |
| 19 | Covent Garden | 3043 | 8099 |
| 20 | Thorney Island | 3022 | 7962 |
| 21 | Clerkenwell | 3166 | 8215 |
| 22 | Rotherhithe | 7600 | 7950 |
| 23 | Uxbridge | 0559 | 8404 |
| 24 | Redcross Way | 3225 | 7980 |
| 25 | Spitalfields | 3348 | 8185 |
| 26 | West End | 2790 | 8100 |
| 27 | Islington | 3080 | 8390 |

Table 12. Sites shown in Figure 26

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Number 1 Poultry | 3258 | 8110 |
| 2 | Regis House | 3288 | 8072 |
| 3 | Guildhall amphitheatre | 3247 | 8135 |
| 4 | Cripplegate Fort | 3235 | 8146 |
| 5 | Forum basilica complex | 3303 | 8110 |
| 6 | Huggin Hill bathhouse | 3223 | 8089 |
| 7 | Walbrook Mithraeum | 3259 | 8099 |
| 8 | St Paul's Cathedral | 3031 | 8084 |
| 9 | Thames Court | 3230 | 8079 |
| 10 | Queenhithe | 3229 | 8077 |

Table 13. Sites shown in Figure 27

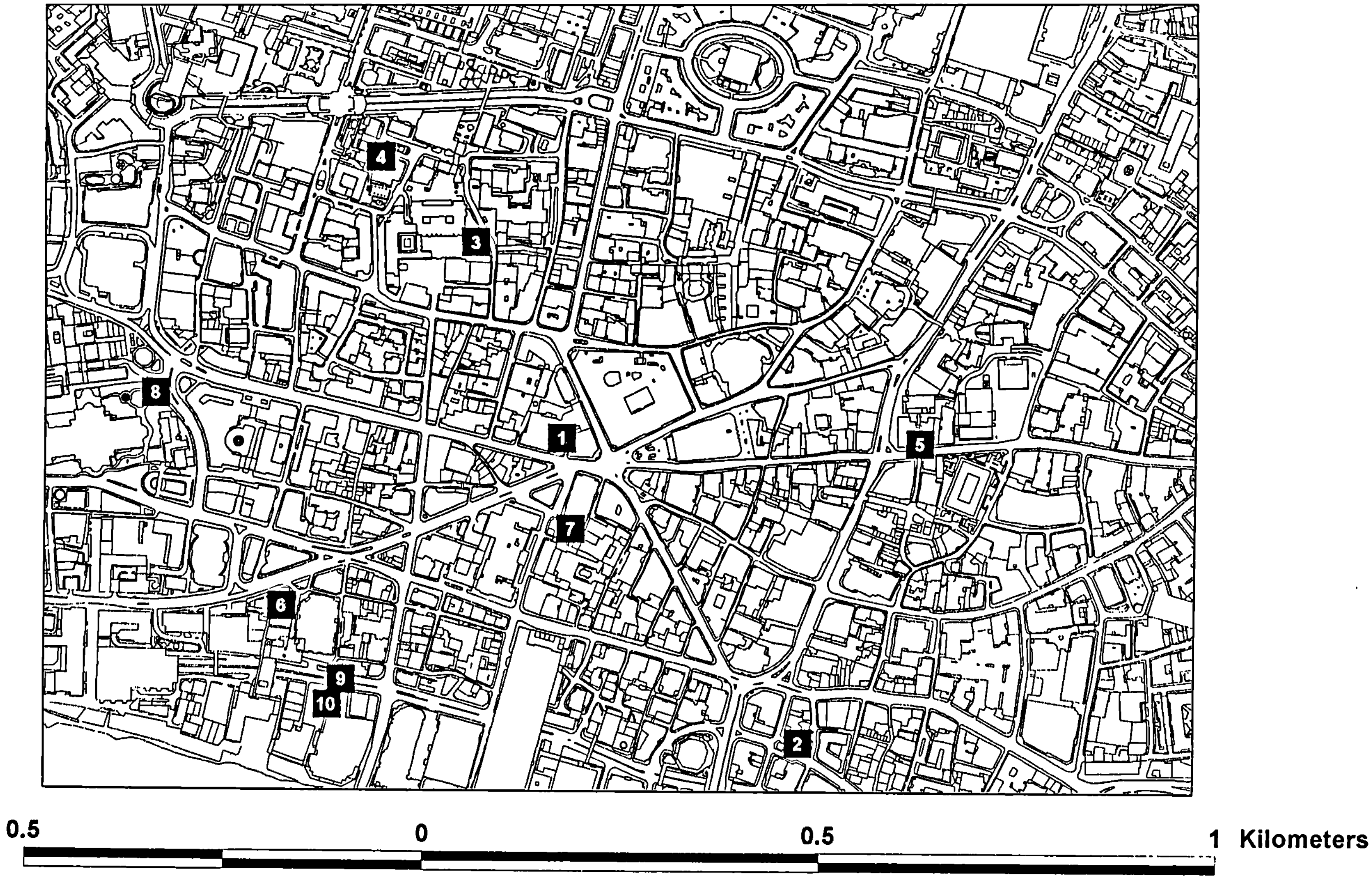



Figure 27. Location map of Roman and post-Roman sites inside the City walls

Figure 28. Reconstruction of *Londinium* in the 2nd century AD, drawn by David Bentley

The hinterland appears to have been used mainly as a farming landscape in order to support the city, not solely for staples such as grain, but also the woodlands on the London Clay appear to have been managed to supply the vast quantities of timber required to build the city as well as fuel it, fuel industries such as ceramic production and build vessels such as boats and carts. There is some evidence for formal land division, whilst many settlements were located at the junctions of differing geologies in order to take advantage, for instance of the gravel terraces for cereal production and also the adjacent floodplain for pasture. Again, the Heathrow area provides some of the best examples of contemporary farming, such as Wall Garden Farm (6 in Figure 26), where several corn-drying ovens have been found, in addition to the field systems (MoLAS 2000, 152). As well as farming settlements, a series of villas are known, most of them at least fifteen kilometres from the city, mainly to the south, for instance at Beddington (7 in Figure 26) and Keston (8 in Figure 26), both of which have Iron Age precursors and were traditional winged corridor types with adjacent bathhouses.

The Roman period saw the first major occupation of Southwark, directly across the Thames from the main city, south of the presumed location of the bridge. It may have been this location at the bridgehead and along the Roman road leading south to the Roman city at Canterbury (*Durovernum*) that led to the intensive settlement of

Southwark. The major focus of the suburb is along the line of Watling Street (now marked by Borough High Street, 9 in Figure 26) and along the waterfront. The south bank consisted of a series of sand islands or eyots with navigable inlets, which reduced the amount of land available for settlement, and signs of reclamation have been observed. Buildings have been recovered from the excavations along Borough High Street (particularly the Northern Line ticket hall site, Drummond-Murray et al. 2002) and at London Bridge (10 in Figure 26) predating the Boudican revolt, indicating that Southwark was settled either contemporaneously with or immediately after the foundation of *Londinium* itself. Southwark was also rebuilt and extended, post-Boudicaa. Borough High Street appears to have become the focus of a bustling commercial centre with a wide range of shops and businesses (Drummond-Murray et al. 1998, 18). Further away from Borough High Street, large stone buildings have been discovered which are possibly town houses of wealthy individuals or prestigious public buildings. As yet, the mechanism leading to the decline of Roman Southwark is not fully understood. It is likely that the suburb decayed along a similar pattern to that experienced by the main centre of *Londinium,* which appears to have been gradually abandoned in the later part of the fifth century after Roman military protection was withdrawn after AD 410, (Esmonde Cleary 1989, 137).

### *The Saxon period (AD 410-1066)*

The Saxon period sees a major change in the form of occupation of London. Initially, there is no firm evidence for what occurred after the removal of 'official' Roman involvement. Occupation carried on; but without protection against the European raiders, the cosmopolitan city life could not continue unchanged. The city is likely to have been gradually abandoned, with a concentration of settlement in the smaller, more defensible towns/villages and also the villa estates. There is only one historical record of London from this period, and the text is from the much later Anglo-Saxon chronicle (Swanton 1996). This cites the mutiny of *Hengist* and *Horsa* and the subsequent battle at *Cregcanford* (Crayford, 11 in Figure 26) when *Hengist* forced the Britons to retreat to *Londinium.*

The archaeological record indicates that by the end of the 5th century, much of eastern England was under Saxon rule. In the London region, the early pagan Saxon occupation took the form of small, isolated villages. There is no evidence for re-occupation of *Londinium*. These villages may have been centered within political territories and have been found in areas such as Hammersmith (12 in Figure 26), Croydon (13 in Figure 26), Kingston (14 in Figure 26) and Harmondsworth (15 in Figure 26). These early settlements tend to consist of series of timber structures, including large halls and smaller sunken-featured buildings. Field systems are often found as well, particularly well represented in the Harmondsworth area (Cotton et al. 1986) and also at Tulse Hill, Croydon (16 in Figure 26). There is very little evidence that these settlements were defended, although there is one possibility at Fulham (MoLAS 2000, 179, 17 in Figure 26).

With the advent of the Christian era, London gained prominence as the primary see of England, with the appointment of Augustine as Archbishop in AD 601. Bede (Colgrave and Mynors 1969) records the commencement of construction of St Paul's (8 in Figure 27) in AD 604 on Augustine's orders. A temporary upset occurred with the reversion of the Kentish peoples to paganism, which involved moving the see to Canterbury until approximately AD 653. The first evidence for London re-emerging as a city comes with a charter of AD 672-4 of Frithuwold of Surrey, who described himself sub-king (Whitelock 1955). The charter identified the 'port of London' and certainly by this period there is archaeological evidence for the initial occupation along the Strand (18 in Figure 26), but also the expansion into modern Covent Garden (19 in Figure 26) of the Saxon port and trading centre. This was described by Bede (Colgrave and Mynors 1969, 142) who identified it as an emporium *'for many nations who came to it by land and sea'.*

The date of foundation is not exactly certain, in fact the site of *Lundenwic* has only been known since the late 1980's following significant re-development of the area around the Strand and Covent Garden (Whytehead, Cowie et al. 1989). The waterfront close to the strand appears to have been the first to be occupied, with the settlement extended along the line of the northern road to encompass modern Covent Garden. It is from the recent excavations under the Royal Opera House in Covent Garden (see Figure 29 below) that the most accurate dates for the foundation of *Lundenwic* come (Malcolm and Bowsher 2002) with high precision radiocarbon dates suggesting that the area was occupied from at least AD 640. The settlement would have compared to *Londinium* as a barn to a palace. The excavations have shown that structures of timber and daub almost certainly with thatched roofs were separated by paths and roads of rammed gravel and general detritus, with yards and open areas cut by vast pits containing more detritus (Malcolm and Bowsher 2002). Amongst these structures, industrial areas for metalworking, textile production and tanning have been found. No public buildings have been identified, no temples, baths or theatres. This could be a factor of the relative insignificance of *Lundenwic* when compared with other towns such as Ipswich or Southampton, or could simply be typical of the Anglo-Saxon way of life.

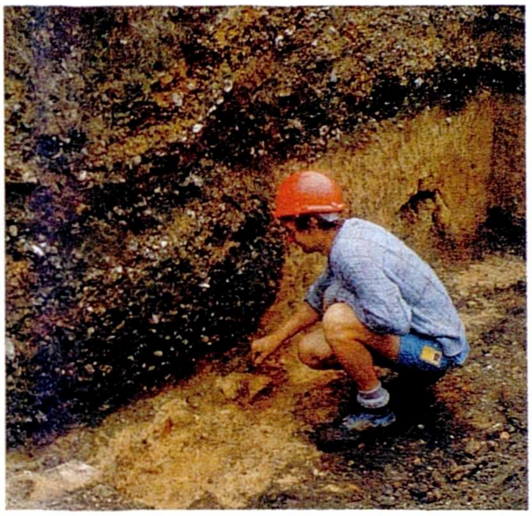


Figure 29. Excavation at the Royal Opera House showing surfaces slumping into earlier pits

The occupation of *Lundenwic* came to an end in AD 886 when King Alfred instructed the community to re-locate within the walls of the ancient city, to afford themselves protection from the Scandinavian raiders who had taken power from sometime in the 870's (Blackburn and Dumville 1998, 122). It is from this period that the defended settlement of *Lundenburh* came into being, with the final defeat of *Lundenwic* and the development of the City waterfront in the Thames Court (9 in Figure 27) and Queenhithe area (Ayre et al. 1996, 10 in Figure 27). The nature of occupation does not seem to change dramatically from the time of *Lundenwic*. Trade and exchange seems still to have played a large part in life, with domestic and industrial clay and timber buildings, a timber waterfront and quayside, roads, alleys and yards; only now the settlement was defended.

A relatively quiet period ensued, identified as an Anglo-Scandinavian phase in London's history. The occupation extended within the City, with distinctive artefacts and even structures identified from excavations at 1 Poultry and also under Guildhall Yard (Bateman 1997); these latter taking the form of timber and turf structures with an attached cemetery. There was also a comparable *burh* established over the river in Southwark. A brief period of rebellion occurred in the 11th century and subsequently, London came entirely under Danish control.

### *The medieval period (AD1066-1538)*

From this date, the town expanded along the major routeways, most notably with the development of Thorney Island, modern Westminster (20 in Figure 26), which became the royal and political centre (Thomas et al. forthcoming). Furthermore, Southwark also expanded significantly owing to the increased traffic to and from southeast England. As well as the royal, administrative and religious buildings of Westminster, a great many houses and shops also sprung up in order for people to be close to the seat of influence. The growing significance of London can be further seen by the number of religious houses and churches that were built in the early medieval period. These perhaps are amongst the most studied aspect of medieval London, potentially as a result of the wide range of evidence, including documentary and cartographic as well as archaeological. A number of these have now been studied in detail and have included a range of orders, such as Augustinian (Thomas et al. 1997), Carthusian (Barber and Thomas 2002), Cistercian (Barber et al. forthcoming) and Cluniac (Steele forthcoming). In addition to the information gained on the lives of the religious communities and those buried within their cemeteries, study of the outer precincts of priories such as the Hospitaller preceptory in Clerkenwell (21 in Figure 26) shows the wealth of craft undertaken within the environs of these establishments, including dyeing, tanning and hornworking (Sloane and Malcolm in prep).

In addition to the fifty-plus religious houses that were constructed, London also saw a series of palaces built for royalty, such as Edward III's palace in Rotherhithe (Blatherwick, in prep, 22 in Figure 26), to the palace of the Bishops of Winchester in Southwark (Seeley, in prep). Manor houses began to spring up in the hinterland, the majority of which were north of the city. Not all of these were attached to farming establishments, however, that was the general trend. In addition to the manorial estates, a network of villages and small towns developed as areas of supply for the city and as market towns in their own right. These included places such as Croydon, Uxbridge (23 in Figure 26), and Kingston, where the archaeology is becoming clearer as a result of increased excavation. London also drew on towns from further away for supplies, such as Henley, which provided grain (MoLAS 2000, 213).

### *The post-medieval period (AD 1538-1800)*

The actual division between the medieval and post-medieval periods is often debated and assigned to different dates, all of which have some merit. The date taken here is that of the dissolution of the monasteries because this led to a significant change in land use, the appearance of the city as well as the less physical changes in power and politics that accompanied the removal of the religious houses and the creation of the Church of England and the elevated role of the monarch. The end date is fairly arbitrary although recent projects have certainly researched deposits post-dating 1800, for instance the study of the paupers cemetery at Redcross Way, Southwark (Brickley et al. 1999, 24 in Figure 26).

By this period, the city was extensive, having infilled and developed along the major routes out of the centre, beyond Westminster (see Figure 31), Spitalfields (25 in Figure 26) and also to the south and the modern West End (26 in Figure 26). The emphasis was more intensively focused on domestic and mercantile accommodation, rather than a city sprinkled with major *foci* such as the religious houses and the royal palaces. The nearby villages had also become more extensive and were now more suburbs merging into the central zone rather than completely separate entities. These include areas such as Islington (27 in Figure 26) and Kingston. Much of the evidence from this period remains in the form of standing buildings, particularly of the post-Great

Fire period. These include obvious public buildings such as Westminster and the Guildhall. In this respect, the study of post-medieval London is undertaken through a variety of means, including cartographic and the Survey of London (Stow 1603). Unfortunately, much of the archaeology has suffered by its proximity to the modern ground surface, i.e. the Rose Theatre (see Figure 30), as well as a lack of interest in a subject only recently fully accepted as an archaeological subdiscipline. As yet, the evidence from the archaeological record is only a small contributor to the overall picture available as a result of the other sources.

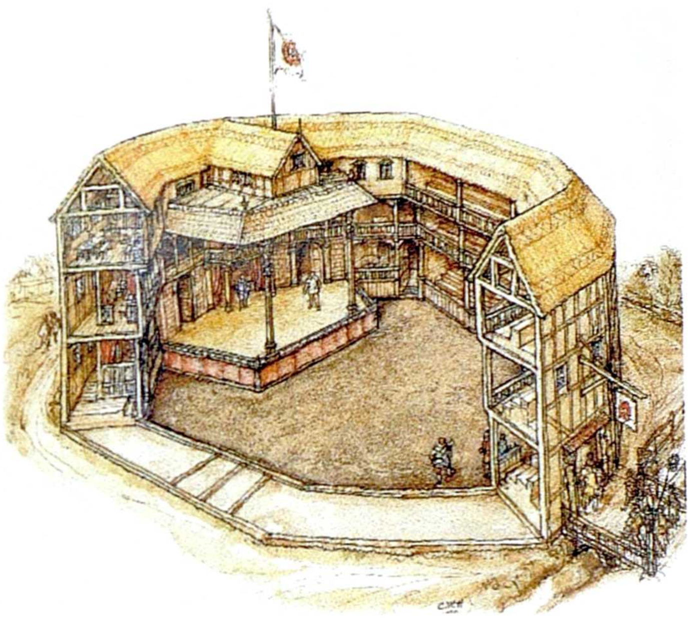


Figure 30. Reconstruction of the Rose Theatre, from Bowsher (1998)

## Summary

The occupation of London has moved from the brief halts of mobile bands leaving an infinitesimal imprint on the landscape, to the inhabitants of a highly complex cityscape composed of buildings ranging from the vast and imposing to slum tenements. The archaeological record reflects this intensification, in that the difficulty of accurately reconstructing and interpreting prehistory is well understood as are the bias' inherent in a region where the historic core has been the favoured area of research. Fortunately, these problems are being addressed and will expand the information of these neglected periods.

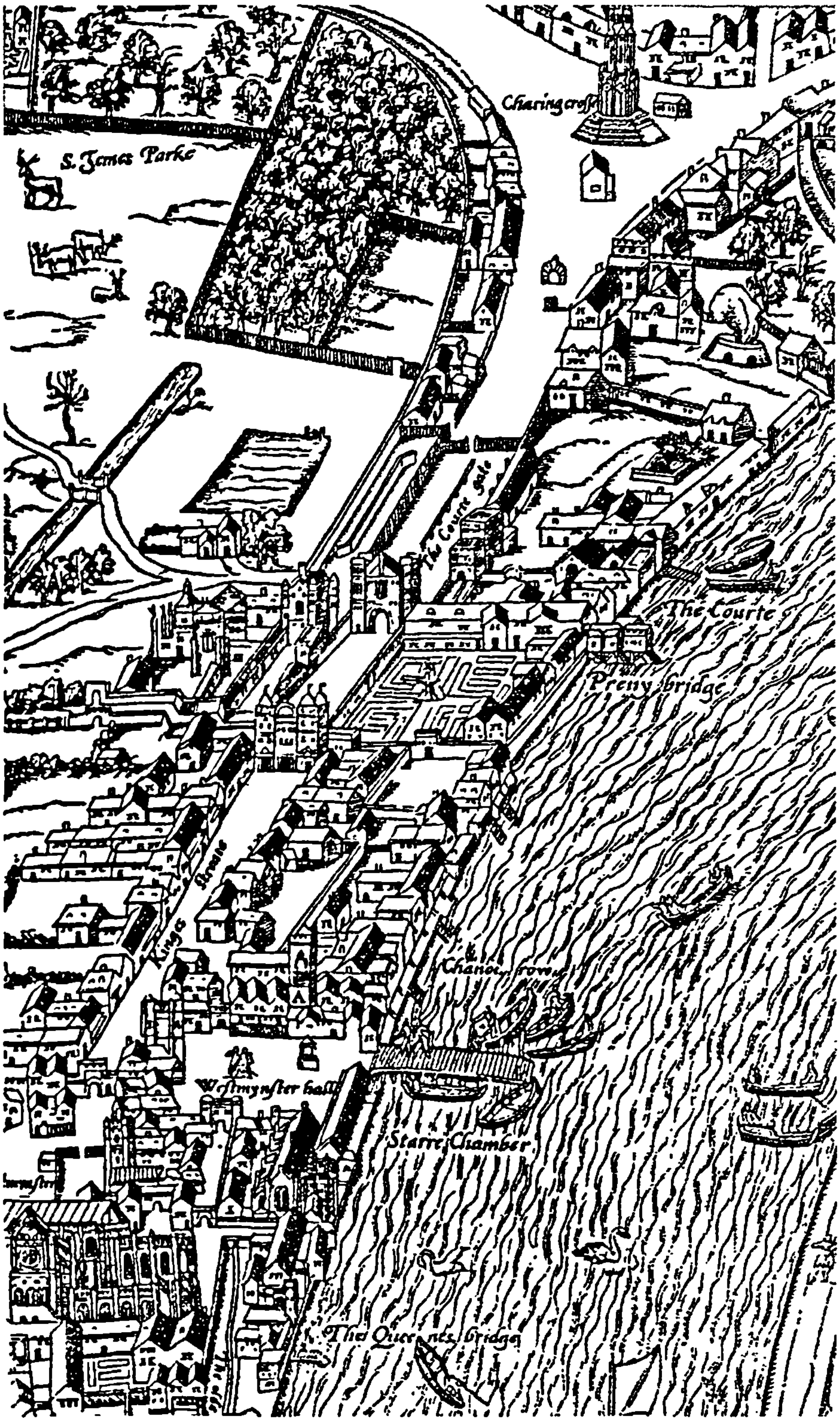



Figure 31. Section from the 16th century Agas map showing the expansion of the City into Westminster

The balance of study varies dramatically from the Lower Palaeolithic through to the post-medieval periods. It is, as yet, practically impossible to make any kind of interpretation beyond the very basic functional level for the Palaeolithic. The detritus left behind by the hominids and early humans is so scanty that it is not possible to do anything other than describe and occasionally classify the material as 'production' 'hunting' or 'base' camp debris. Sadly, the early prehistoric evidence is from a wildly biased dataset; much of it collected by antiquarians, often bought from dredgermen or gravel diggers who are likely to have concealed the true origin of the finds in order to protect their site and who only collected intact and large pieces (Cotton 1999). The remainder of the dataset has been collected by scientific excavation, but forms only a very small proportion of the total. Fortunately, at this date, topography and climate change are likely to have been enormously influential factors in peoples lives. It is much more possible to undertake detailed research in the field of landscape archaeology in this period, rather than on the artefacts themselves. The dataset is still restricted; limited to relatively few well-preserved sequences, (generally from the interglacials), nevertheless, more sites will be acquired over time, as a result of better legislation and the current renewed interest in environment and early human evolution. There are better datasets from the Holocene, with a much more representative and more scientifically studied resource. Additionally, the Holocene archive tends to have been created more recently, and consequently is better cared for, with records and finds available for re-examination.

In the more recent past, environment and climate are seen as less important determining factors affecting human existence. This is very obviously a result of the less extreme changes in environment present to date in the Holocene in combination with the development of material culture and social evolution. This may be seen particularly with the advent of ceramic and metal technologies and the necessary social structures that would have been required to initiate monument construction and communal farming. The importance of understanding the interplay of social structure, development of technology, material culture and ritual beliefs and practices has dominated the archaeology of the Holocene, relegating environment very much to a simple and basic backdrop to culture. Arguably, this has perhaps gone too far, where the school of post-processualism has demoted factors other than cognitive to the scrapheap. And yet, in London, the river at least has played a key role in the development of the historic town.

The balance between social theory and environmental reconstruction has yet to be struck, but it is gradually being worked towards in the archaeology of London.

The changing level of the river is likely to have been of significance in the prehistoric period particularly. This is from a conceptual point of view, in that the movement of water on tidal scales may well have been considered an extremely strange phenomenon. This depends very much on the migration routes of the peoples in question, nevertheless, the relationship of river and sea may not have been fully understood, and therefore, the movement of the tide upstream may well have caused some disquiet and thoughts of magic. An example of this may have recently been noted at Vauxhall (Sidell, Cotton et al. 2002) where a possibly ritual structure has been recorded, with a placed deposit of two spearheads. The structure dates to the mid Bronze Age, at a time when tidal waters were moving through this area. On a more practical level, it is apparent that the margins of the floodplain were used for a variety of purposes and therefore, loss of land would have been inconvenient at the least. It is unlikely that it would have happened at a speed that meant it would not have been possible to make changes to settlement patterns, but the loss of regular field systems, such as those in Southwark would almost certainly have been awkward. The requirement to move the Roman waterfront on the north bank of the Thames is likely to have been rather more than simply awkward in that it would have been a major piece of construction. The adaptation to changes required by the movements of the river is a fascinating piece of research.

In terms of archaeology, no other English estuary can boast the same intensity of occupation. This is very obviously owing to the presence of historic London and the hinterland. Nevertheless, the prehistoric occupation in the Thames is also substantial, demonstrated by recent fieldwork. It is comparable with the prehistoric occupation of the Severn (Allen 1996; Allen and Rippon 1997; Bell and Neumann 1997; Bell, Caseldine et al. 2000; Rippon 1997) and the Humber (e.g. Van de Noort and Ellis 1995; Van de Noort and Ellis 1998) and therefore the importance of developing an understanding of sea level change is directly relevant the study of human occupation in the Thames Valley.

# *Chapter 3. Methods*

## 3.1 Introduction

This section outlines the methods used in the primary analysis undertaken for this thesis. The techniques are discussed alongside the reasons for selecting them. This is not exhaustive as the techniques are not new and have been extensively detailed elsewhere.

## 3.2 Sample recovery

This section outlines the methods of data collection and the analytical procedures. All sites were sampled either by face section sampling (see Figure 32) or through the collection of U4/100 samples using a cable percussion rig. Where face sections were available, samples were collected from the most representative location of the overall stratigraphy. All contaminated or anomalous areas were avoided. Monolith tins were used to collect undisturbed samples through the sediment stack. The tins were constructed of stainless steel, with dimensions of 500x50x50mm. These were lined with plastic drainpipe to enable removal of the core from the tin. All samples were overlapped in order to ensure complete recovery. Tins were marked with the sitecode, i.e. WW-PS94 at North Woolwich pumping station. Other information marked on the samples includes the number of the tin within the sequence, the top, bottom and overlap with adjacent tin(s). These samples were then recorded on section drawings and leveled to Ordnance Datum (OD). They were then carefully cut away from the section, wrapped in plastic and sealed for safe transport. When not cleaned and described immediately, they were placed in cold storage, kept at approximately 3° centigrade. The coding assigned to each site is the unique identifier ascribed by either the Museum of London or Newham Museum where the site archives are held for consultation and also at the GLSMR at English Heritage (EH). Unfortunately, the majority of the cores are no longer extant as they were discarded by the Museum of London.

Bulk sediment samples were taken adjacent to the series of monolith tins. These were collected for a variety of techniques, such as radiocarbon sampling. The methodology for collecting these varied slightly from site to site, but generally followed a consistent pattern. The section was cleaned and recorded and samples were incrementally cut from the section and placed into sample buckets or bags. All potentially contaminated and anomalous areas were avoided. The samples were collected in a consecutive numbered sequence, controlled by volume. This was generally 300x300x50mm. Samples were double labeled and stored cool until required. Collection by volume rather than weight is preferable, owing to the varying densities of the sediment types encountered (Evans and O'Connor 1999, 121; English Heritage 2002).

Figure 32. Face section sampling using monolith tins

U4/100 samples were collected using commercial drilling rigs. Samples were collected as continuously as possible, with all cutting shoe samples retained as semi-disturbed samples. The U4/100 samples were extruded using a mechanical device and the samples transferred from the U4/100 tubes to split terrain pipe, labeled at the top of each sample, wrapped in plastic and transferred to cold storage. Following sedimentary description the monolith and U4/100 samples were used to provide additional subsamples; 10mm thick subsamples were cut using clean scalpels and knives for loss-on-ignition, magnetic susceptibility and diatom analysis.

Several problems exist with these types of sample collection. Cable percussion rigs can provide samples from deep sequences, which are not always accessible on archaeological sites. However, the method can lead to both compaction of non-plastic sediment such as peat and also stretching of the more plastic deposits such as clay. This can obviously cause problems when reconstructing altitude and sedimentation rates. Nevertheless, this is likely to be relatively insignificant when compared to the overall compaction occurring within the sequence since deposition. On the whole, sampling with monolith tins is generally preferable. The sections are visible; they can be studied and drawn before the sample location is selected. Also, the sections can be properly surveyed and leveled, which is much more difficult with a borehole. The only real drawback is that standard size monolith tins do not provide large enough quantities of sediment for the full range of techniques to be applied.

## 3.3 Sedimentology

All sediments retained within the sample tin/terrain pipe were cut down to create a flat face and cleaned horizontally using a scalpel to avoid smearing. The sequences were then described from the base of each sample up, starting at the base of the sequence and using the Troels-Smith (1955) system of sedimentary classification (see Figure 33). The system was slightly modified to allow colour to be ascribed using the Munsell system and to allow additional comment for extended description of aspects such as the nature of the contacts (Jones 1999, 29), which, within the confines of the system as it stands can only be numerically coded. Data were entered onto *proforma* sheets and subsequently transferred to a Microsoft EXCEL spreadsheet (see Figure 34). These logs are present in appendices 1-7, where the sequences are also described in summary form, identifying peats, mineral sediment and organic mud. This last term is used to refer to sediment, which is a mixture of degraded organic matter, and silt clay, but is neither a peat nor pure mineral sediment. These units are commonly found within sequences of waterlain sediment and can represent a number of distinct depositional environments. Organic mud is often termed gytjja. The Troels-Smith system was selected for several reasons. Although archaeologists do not use it, it is extensively used within the earth science community and therefore it was appropriate to produce the collected data in a form accessible to other workers who may have an interest. Furthermore, owing to the coding and use of 'Latin' nomenclature, it is an international system (Long et al. 1999). An additional point in its favour is the detail required for description of organics; many of the sediments reported on in this thesis are wholly or partly organic and therefore, once again, the system displays advantages over others which are not so rigorous.

**USE OF THE TROELS-SMITH SYSTEM OF SEDIMENTARY CLASSIFICATION**

The system is used to characterise sediment, and can be divided into physical characteristics, the component parts and degree of humification. These are all defined and applied through a scoring system. Additionally symbols exist for graphical presentation of the sediment types. These are not shown in this guide and the 1955 paper should be referred to.

**PHYSICAL CHARACTERISTICS**
Scores of between 1 and 4 can be obtained for each characteristic, with 0 (no demonstration of characteristic) and 4 (total demonstration of characteristic). Scores of 1-3 are intermediate (quartile stages).

| | | | | |
|---|---|---|---|---|
| NI | *nigror* | darkness | 0-4 | 0=clear/white (i.e. quartz) 4=black (i.e. completely disintegrated peat) |
| ST | *stratificato* | stratification | 0-4 | 0=complete homogeneity 4=very finely laminated |
| EL | *elasticitas* | elasticity | 0-4 | 0=total absence (i.e. plastic clay) 4=very clastic (i.e. fresh peat) |
| SI | *siccitas* | dryness | 0-4 | 0=clean water 4=air dry deposit |
| CO | | colour | | use Munsell colour chart |
| ST | | structure | | use comment field |
| LI | *limes* | boundary | 0-4 | 0=>10mm 1=10-2mm 2=2-1mm 3=1-0.5mm 4=<0.5mm |

**DEPOSIT COMPONENTS**
A total of 4 can be scored for components. This can be one component forming the total and therefore obtaining a score of 4, or several components all scoring between 1 and 3 to a total of 4, e.g. Th 2 Dl 2. Components scoring less than 1 (i.e. less than a quarter of the component elements are marked as "+". Indications of the types of vegetation present can be described by inserting and abbreviation in parenthesis after the code for the component, e.g. Tb 4 (*Spha.*) (*Sphagnum* peat), or Th 4 (*Phra*) (*Phragmites* peat)

Humicity - *humositas* - the degree of disintegration of organic component/structure
Scored 0-4 0=fresh structure 4=plant structure absent of barely discernible plant structure.
The score is applied (in superscript) to the organic deposit components, i.e. a fresh moss peat with no other component elements would score $Tb^0$ 4, while a semi degraded moss peat would score $Tb^2$ 4

**COMPONENTS**
Substantia humosa completely disintegrated or nearly disintegrated organic substances or precipitated humic acids without macroscopic structure

*Turfa* mosses and roots of woody or herbaceous plants (includes the rest of the plant if attached to the roots, demonstrates macroscopic structure. Divided into:

| | | |
|---|---|---|
| Tb | *Turfa bryophytica* | Moss |
| Tl | *Turfa lignosa* | Wood |
| Th | *Turfa herbacaea* | herbaceous plant fragments |

*Detritus* fragments of the superterreanean parts of plants >1.0mm. Divided into:

| | | |
|---|---|---|
| Dg | *Detritus granosus* | fragments of ligneous and herbaceous plants <2mm |
| Dh | *Detritus herbosius* | fragments of herbaceous plants, e.g. leaves, stems >2mm |
| Dl | *Detritus lignosus* | fragments of ligneous plants >2mm |

*Limus* mud like homogeneous non-plastic deposit. Divided into:

| | | |
|---|---|---|
| Ld | *Limus detrituosus* | Homogeneous soil |
| Lso | *Limus siliceous organogenes* | skeletons of plants or animals, e.g. diatoms (use comment field if can demonstrate presence) |
| Lc | *Limus calcareous* | non-indurated homogeneous soil consisting of $CaCO_3$ |
| Lf | *Limus ferrugineus* | iron oxides. If nodular and >0.1mm classified as *Grana* |

*Argilla* mineral particles or <0.06mm

| | | |
|---|---|---|
| As | *Argilla steatodes* | colloids or grains <0.002mm |
| Ag | *Argilla granosa* | grains from 0.06-0.002mm |

*Grana* solid particles >0.06mm, mineral or organic

| | | |
|---|---|---|
| Ga | *Grana arenosa* | 0.06-0.6mm |
| Gs | *Grana saburralia* | 0.6-2.0mm |
| Gg | *Grana glareosa minora* | 2-6mm |
| GG | *Grana glareosa majora* | 6-20mm |

Accessory element, i.e. artefacts, molluscs should be listed in the appropriate field

Figure 33. Code sheet used to complete the Troels-Smith proformas

| Troels-Smith Classification Sheet | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site Code: | | | | Address: | | | | | | | | | | | | | | | | | | | | | OD top: | |
| | | | | Described by: | | | | | | | | | | | | | Date: | | | | | | | | OD base: | |
| Unit | Tin | Meas. | *Physical Properties* | | | | | | | *Turfa* | | | *Detritus* | | | *Limus* | | | *Argilla* | | *Grana* | | | | Accessory | Comment |
| | | | NI | ST | EL | SI | CO | LI | Sh | Tb | Tl | Th | Dg | Dh | Dl | Ld | Lc | Lf | As | Ag | Ga | Gs | Gg | GG | elements | (inc. Structure, Lso) |
| 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 34. Troels-Smith *proforma* sheet

### Magnetic Susceptibility

Magnetic susceptibility was selected as an analytical methodology to assist with characterization of the sedimentary sequences. This type of analysis is becoming more commonly undertaken through sedimentary sequences on archaeological sites (Allen 1986, 1988, 1990) as a means of assessing human effect on sedimentation through, for instance, burning (Bellomo 1993), agriculture (Lageras 1994), in addition to providing information on the presence of palaeosols/iron pans and pedogenesis (Thompson and Oldfield 1986). These lead to modification and enhancement of the 'natural' magnetic signal present in soils and sediments. Therefore, modified soils or sediments will be distinct from those that have not, and this difference can be easily observed by measurement of the magnetic properties (Walden et al. 1999, 5). Close interval measurement of sedimentary sequences can indicate whether specific events have occurred, or whether the sequence (and presumably site/local area) has remained unchanged over the period in question. Although it is more often used as a geophysical prospection tool within archaeology (Clark 1996a; English Heritage in press), its value in attempting to locate human activity through time as reflected in deep sequences is becoming more widely known (Walden et al. 1999, 218-9) and is now an important technique for the classification of sedimentary sequences in archaeological contexts. Recent examples include the work of Crowther (2000, 57) at Goldcliff in the Severn estuary and at Overton Down (Clark 1996b, 118).

The subsamples obtained from the selected cores were initially air dried at temperatures of <40°C. This temperature requirement was in order to avoid affecting the magnetic properties of the sample, which can be modified if exposed to temperatures in excess of 40°C. These were then manually ground in a mortar and pestle, sieved through a 2mm mesh and placed into weighed (to two decimal places), numbered 10cl plastic lidded pots. The pot, lid and sample therein were re-weighed. The analytical procedure then followed that of Gale and Hoare (1991, 204-220) for low frequency ($\chi^{lf}$) measurement, using a purpose-built Bartington MS2 magnetic susceptibility sensor and meter. Prior to each run of samples (generally fifteen samples), the meter was zeroed. An air blank was measured for ten seconds; these do not generally register zero, owing to factors such as air movement, temperature swings and machine drift. Following the air blank, the sample was placed in the meter, and measured on low frequency for 10 seconds. The sample was then removed and a further air blank was taken. The 'drift' factors may continue to operate whilst the actual magnetic susceptibility sample is being measured; hence the need for two blanks before and after the actual measurement is taken. These were then combined and a mean calculated with the result being deducted from the actual magnetic susceptibility reading. The calculations also standardized all samples to a consistent weight. On completion the data were transferred to Microsoft EXCEL to calculate mass specific susceptibility ($\chi^{lf}$) and to facilitate graphic presentation. The graphs may be found in appendices 1-7.

## Loss-on-ignition

Loss-on ignition was also selected as an analytical method to assist with the characterization of the sedimentary sequences. Although a simple technique, loss-on-ignition may be a highly accurate way of tracking change in processes leading to sedimentation and fluctuations in the depositional environment such as peat beds (Mills 1994) and coastal and estuarine sequences (Zong and Horton 1998). With deposits such as those encountered for this thesis, it is particularly useful where the sedimentary architecture is comprised of intercalated organic and minerogenic sequences. The resultant data can also be used to examine the sequence for unconformities and hiatus' where rapid changes in organic content may be a result of erosion. As with the magnetic susceptibility, recent examples may be found at Overton Down (Crowther 1996, 112) and Goldcliff in the Severn estuary (Crowther 2000, 57).

The subsamples that had been used for the magnetic susceptibility measurements were subsequently used for the loss-on-ignition measurements. This was done in order to determine organic carbon content as a proportion of total sediment mass. Loss-on-ignition procedures followed that recommended by Gale and Hoare (1991, 262-4). The samples contained within the plastic pots used for magnetic susceptibility were transferred to weighed (to two decimal places), numbered porcelain crucibles. These with the sample were re-weighed and then fired in a Carbolite muffle furnace at 550°C for four hours. The crucibles and remaining sediment were re-weighed. The weight loss was expressed as a percentage of the original sediment and provides detail of the original organic carbon content. Data were entered, manipulated and illustrated graphically using Microsoft EXCEL. The graphs may be found in appendices 1-7.

## 3.4 Radiocarbon dating

Radiocarbon dating has been used to establish the chronologies for the major sites in this project where there has tended to be an absence of archaeological features owing, in part to the criteria used for site selection. Therefore, it was not possible to date them using established archaeological methods such as artefact typology (Renfrew and Bahn 1996, 116-118) or dendrochronology (Baillie 1997). Subsamples containing organic material were either taken from bulk samples or split from the monolith/U4 samples for radiocarbon assay. The radiocarbon method has been published in detail (for instance, Aitken 1990, 56-119), and elements of it are constantly being refined, for instance the calibration curve (see Stuiver et al. 1998).

Radiocarbon is a particularly good radiometric dating technique for the Holocene. The method relies on the presence of different, but measurable, isotopes of carbon occurring within every living organism. It is the presence of the different isotopes that makes the method possible as it is the ratio of $^{14}C$ (radiocarbon) to $^{12}C$ and $^{13}C$ that is measured. $^{14}C$ (the unstable, radioactive isotope) decays at a known rate (the half-life) whilst the other two remain stable. Therefore, by measuring the proportion of $^{14}C$ to $^{12}C$ and $^{13}C$ it is possible to determine when the organism died. The half-life of $^{14}C$ is currently determined as $5730 \pm 40$ years (Godwin 1962). However, it was previously identified as $5568 \pm 30$ years (Libby 1955) and this has been accepted as the standard for calculation of measurements in order to maintain consistency of results measured before 1962 (Lowe and Walker 1997, 240-247).

There are a series of assumptions, (all of which are subject to challenge) on which the technique is underpinned. These are:

- *That the measured decay rate is accurate*
- *That $^{14}C$ has been available through the geological/archaeological record*

- *That the ratio of $^{14}C$ and $^{12}C$ has remained stable between the atmosphere and the bio/hydrosphere,*
- *That no $^{14}C$ has been re-introduced into the organism since it died*

These are generally accepted as given, although, as identified above, the half-life has been re-measured once, furthermore, issues with $^{14}C$ re-entering the organism through dissolution and mobilization of calcium in which organisms have been buried have also been raised. More critically, research initially undertaken by de Vries (1958) showed a discrepancy in production of $^{14}C$, which, through dendrochronology indicated that radiocarbon years can differ significantly from calendar years and this becomes particularly marked the further back the measurements go.

Following on from the issues associated with the technical assumptions come problems associated with the samples themselves. As mentioned above, the technique dates the death of the organism being submitted for assay. This may not have occurred at the same time as the event/structure being dated, i.e. timber being used for a prehistoric round house may have come from a tree which died many years previously and has been re-used from earlier buildings. Wood may also have drifted within a river system for many years before being finally incorporated into a sedimentary sequence, whilst smaller organisms such as mollusc shells may have eroded from earlier deposits. As well as lateral displacement, there may be vertical movement of biological material, such as the downward penetration of roots, which, if measured, could lead to dates given to horizons in the sequence being 'too young'. All these issues such as problems with $^{14}C$ ratio fluctuations in seawater mean that samples must be selected with great care and that all the issues must be borne in mind when interpreting the data, analyzing sequences, events and consequently sites.

A combination of conventional radiometric, extended counting and Accelerator Mass Spectrometry (AMS) techniques has been used in this research. Conventional counting is undertaken by counting beta particles emitted from the samples, which are present as specific decay products. This is done either through conversion of the samples to benzene (liquid scintillation counting) or conversion to carbon dioxide, methane or ethylene (gas proportional counting) (Lowe and Walker 1997, 241). Extending counting simply allows the sample to be measured for a greater length of time, and is done in cases where the sample had a low carbon yield. AMS dating is generally undertaken on very small samples and uses a mass spectrometer to count $^{14}C$, $^{13}C$ and $^{12}C$ atoms from a sample that has been converted to graphite, which is bombarded with caesium ions, deflecting the $^{14}C$ from the $^{13}C$ and $^{12}C$.

Measurements undertaken by these various counting methods result in age ranges presented in *radiocarbon* rather than *calendar* years. These are not the same length and initially this was not comprehended, therefore early measurements were thought to be in calendar years. The problem is associated with fluctuations in atmospheric radiocarbon, which is not consistently present within the atmosphere and therefore take-up by living organisms is also inconsistent. The most spectacular demonstration of this came with the advent of atomic bombs, which injected radiocarbon in enormous quantities into the atmosphere, completely destroying the 'natural' ratio of stable: unstable carbon isotopes. This subsequently led to the introduction of a cut-off date of 1950 in radiocarbon analysis. The difficulties were resolved through tree-ring dating. A calibration curve (see Stuiver et al. 1998) for the latest version) has been constructed using dendrochronology to calibrate samples with known radiocarbon values. This means that measurements given in radiocarbon years can be matched to the curve and a date range in actual calendar years may be read from the curve. Although some researchers prefer to work in radiocarbon years, chronologies are only understandable when calibrated owing to the fluctuating time depth within sequences in radiocarbon years.

Beta Analytic Inc., Miami, measured all samples from the analyzed sites with the exception of the AMS dates, which were measured at Kiel, Germany. Full references are given in the text and appendices. The results presented throughout the text and appendices are conventional radiocarbon ages (Stuiver and Polach 1977) and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). The dates used in this thesis have been calibrated with data from Stuiver et al. (1998) using OxCal (v. 3.5) (Bronk Ramsay 1995; 2000). The date ranges have been calculated according to the maximum intercept method (Stuiver and Reimer

1986) and are cited in the text at two sigma (95% confidence). They are quoted in the form recommended by Mook (1986) with the end points rounded out to 10 years.

## 3.5 Biostratigraphy

### Diatom analysis

Diatoms are unicellular algae abundant in all aquatic conditions. They were selected as the key microfossil group which could be used from the site cores to attempt to reconstruct local environmental conditions and be most appropriate to address the question of marine influence upon the sites and environments under study (see Mannion 1987; Juggins and Cameron 2000). Diatom analysis is generally used by sea level researchers to fulfill the criterion of biological indicator required to construct index points (Tooley 1978b; Horton and Edwards 2000). Diatoms were used by Devoy (1979); other researchers using diatom analysis on the Thames includes Boyd (1981), Milne et al. (1983), Battarbee (1988), Juggins (1988, 1992) and Cameron (in Sidell et al. 2000). This has included work on sea level reconstruction, salinity transfer functions and also historic pollution. The other key proxy indicators are foraminifera. These have been used as biological indicators by many other sea level researchers (Edwards 1998; Edwards and Horton, 2000; Horton and Edwards 2000; Lloyd 2000; Shennan et al. 2000). Nevertheless, diatoms were selected for this research in order to be able to make valid comparison with extant research in the Thames. Furthermore, there is a school of thought that suggests results from diatoms may provide more useful results than foraminifera (Charman et al. 1998; Gehrels et al. 2001).

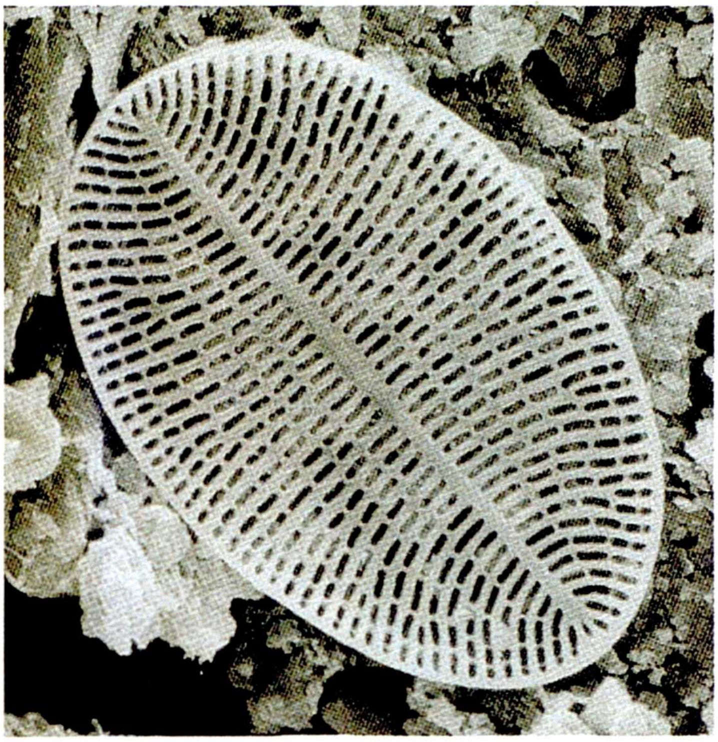


Figure 35. The estuarine diatom *Cocconeis placentula*

Diatoms are composed of a silica frustule formed of two overlapping valves held with girdle bands. Identification is based mainly on the surface morphology and sculpturing on these valves (Round, Crawford et al. 1990). There are problems associated with the use of diatoms as proxy ecological indicators, including highly variable preservation between species and sediment types, poorly understood taxonomy and taphonomy of fossil assemblages. Key examples of research using diatoms to assist in the reconstruction of RSL change in England include Shennan (1980, 1982) in the Fenlands, Long (1991, 1992) in the east Kent Fens, Kirby in the Humber estuary (Kirby 1999) and Cameron and Dobinson in the Severn (2000, 262). The ecology is complex with a range of habitats colonized by different diatom types. Their classification by habitat types (Anderson and Vos 1992) include:

- *planktonic - in freely moving water,*
- *epiphytic - attached to submerged plants.*
- *epipsammic - attached to mineral sediment such as sand,*
- *epipelic - dwells in mud*

- *epilithic - attached to rocks*
- *aerophilious - in occasionally dry pools and saltmarshes*

Preparation followed standard procedures (Battarbee 1986). Cleaned solutions from each subsample were evaporated on 2 coverslips at differing concentrations and were mounted in naphrax. Slides were examined using Nikon and Olympus research microscopes with phase contrast illumination at a magnification of x1000 or x1200. Identifications were made using the collection of diatom floras and publications lodged at the sea level research unit, Department of Geography, University of Durham, the Environmental Change Research Centre (ECRC), UCL and the Institute of Archaeology, UCL. These floras included (Van der Werff and Huls 1957-1974; Hendey 1964; Barber and Haworth 1981; Snoeijs 1993, 1994 and Hartley 1996).

Specific identifications were made wherever possible, with identifications to genus otherwise. Only whole or almost complete valves were counted; half counts were not made. As diatoms are being used as a tool to assist in the construction of index points and identify the nature of environmental change at stratigraphic boundaries, minimum counts of 200 valves were made (Battarbee 1986) rather than the higher counts recommended for complete botanical analysis. Some samples were not considered countable, owing to a dearth of valves; in such cases, the few identifications that were made have been included on the spreadsheets, along with the number of traverses taken to achieve them.

Taxonomic nomenclature follows Hartley (1986), although some variations in nomenclature have occurred since this was published and the most modern, accepted name has been taken where this is the case. Diatom species have been assigned to halobian groups according to the system of Hustedt (1953, 1957) in order to create groupings that may then be used to discuss the ecology of individual samples. The principle sources of data on species ecology used were the survey of Denys (1992) and the groupings of Vos and de Wolf (1993). Other works used to assist with ecological classification include (Zong 1998; Zong and Horton 1998; Zong and Horton 1999). Diagrams have been prepared using Tilia and TiliaGraph (Grimm 1991) and were modified at the ECRC, UCL using TRAN (Juggins 1994). The diatoms in the halobian groups used in the diagrams have optimal growth in water with salinity equivalent to the ranges proposed by Hustedt (1953, 1957) (see Table 8).

| Halobian group | Salinity preference |
|---|---|
| Polyhalobian | >30g $l^{-1}$ |
| Mesohalobian | 0.2-30g $l^{-1}$ |
| Oligohalobian halophilous | optimum in slightly brackish water |
| Oligohalobian indifferent | optimum in freshwater but tolerant of slightly brackish water; unknown, taxa with unknown salinity optima |
| Oligohalobian halophobous | restricted to freshwater environments and are intolerant of brackish and marine waters |

Table 14. Halobian system after Hustedt (1953, 1957)

## Pollen

The pollen assessments mentioned in Section II of thesis were carried out by Dr. Rob Scaife and are quoted with his permission. Several assessments of pollen preservation were undertaken as part of the standard archaeological evaluation procedure. In the cases where pollen results were obtained, these have been described. As with diatom analysis, there are a number of problems with pollen analysis, again mainly concerned with variable preservation of species and within varying sediment types, particularly associated with pH and moisture content. Furthermore, there is potential for great bias in the record resulting from dispersal methods; the pollen of some species such as *Pinus* (pine) can travel substantial distances from the place of origin whereas others such as *Tilia* (lime) will travel practically no distance at all (Waller 1994b). This is of course exacerbated in situations where pollen grains may be reworked and retransported, for instance by water. Nevertheless, pollen analysis can be invaluable for examining ecological conditions and landscape evolution and combined with this is the possibility of tracking anthropogenic modification with large obvious events such as forest clearance, introduction of arable cultivation and subsequently exotic species.

Standard techniques were applied; the monolith tins and U4/100 core were subsampled in a manner similar to the diatom subsamples (split off in 10mm slices) at varying intervals throughout the sequences, generally targeting the organic strata and contacts between organic and minerogenic sediments. Extraction procedures followed those outlined by Moore and Webb (1978) and Moore et al. (1991). Samples were deflocculated using 8% potassium hydroxide and coarse debris removed through sieving at 150µm. Fine inorganics were removed by micro-mesh sieving at 10µm and the remaining silica was digested with 40% hydrofluoric acid. Finally Erdtman's acetolysis was carried out to cellulose. The concentrated pollen and spores were stained with safranin and mounted in glycerol jelly. Pollen grains were then identified and counted using an Olympus biological research microscope with phase contrast facility at magnifications of x400 and x1000. Throughout the text taxonomy follows Moore and Webb (1978) and Stace (1991). The first mention of a species is translated into the common name and continued reference is made in Latin thereafter.

### Plant macro-fossils

As with the pollen, some plant macrofossil assessments were undertaken as part of the standard archaeological projects. Dr. Andy Fairbairn undertook this work and the data are incorporated with his permission. Plant macrofossil evidence tends to be used in association with other proxy indicators such as pollen and invertebrate as plant macrofossil data is subject to a number of problems such as differential preservation, restricted identification (only the seeds are generally identified) and the more general taphonomic factors such as representivity and integrity of assemblages.

Subsamples were taken from the bulk samples collected on site in association with the monolith samples and were processed by washing through a 250µm sieve and then placing in jars filled with 90% industrial methylated spirits. Seeds and other plant material were identified under a binocular light microscope with reference to a modern comparative collection held at the Museum of London and plant catalogues, for instance (Berggren 1981). Throughout the text taxonomy follows that of Stace (1991). The first reference to an individual species is translated into the common name and continued reference is made in Latin thereafter.

## 3.6 Relative sea level

In order to make comparison between different locations, the age/altitude points of the individual samples were converted using the following formula suggested by Professor Ian Shennan of the University of Durham. This formula has been used for the British database of sea level index points, held in the Department of Geography, University of Durham and therefore the index points used in this thesis may be used with the British dataset.

The formula is:

$X = ALT + ID - RWL$

Where:

X = relative sea level

ALT = the altitude in metres OD (Newlyn) of the sample (taken as the mid point of the sample)

ID = the indicative difference of the sample

RWL = the calculated reference water level (see below)

### Indicative difference

The distance from the mid-point of the indicative range to the reference water level.

### Reference water level

The reference water level was calculated according to the formulae in Shennan (1994, 54, table 5.2) using altitudes (metres OD) of MHWST and HAT taken from the nearest tide gauge station to the sampling site in question.

### Errors

The mean tide level error was calculated by application (and slight modification) of the following formula.

$X = O\ (A2 + B2 + C2 + D2 + E2 + F2)$

Where:

A = the leveling error associated with the sample

B = the sample thickness

C = the tide level error of the sample

D = the altitudinal difference between the two nearest tide gauge stations

E = the indicative range of the sample

F = the compaction error introduced during sampling and extrusion.

A. Two forms of leveling error have been used. During sample recovery on the trenched OD heights were recorded on the top of the tins from either dumpy levels or total sta theodolites
(TST) using local control to the Ordnance Survey (OS) National Grid. Therefore the error was low, estimated as 20mm (± 10mm) as the error required on a closed traverse on most archaeological sites in London is generally 10mm or less. Heights calculated on borehole rig sampling are necessarily cruder, although of course they are still recorded to local control points of the National Grid. Depths are measured from the ground surface using a tape measure or marks on the cable of the rig; therefore greater errors are encountered than when the samples are visible. These sites have been allocated a leveling error of 50mm (± 25mm)

B. This is the thickness of the dated sediment and is recorded in the appendices for all sampled sites. The mid point of the samples was used as the altitude of the sample.

C. This is the tide level error of the sample, indicated (Shennan 2000) as ± 0.1m, as assigned in the Admiralty tide tables.

D. This was not used as only the nearest tide gauge station was used.

E. The indicative range associated with the reference water level was applied with reference to Shennan (1994, 54, table 5.2) following assignation of a tendency code, again with reference to this same paper.

F. This was not directly measurable and therefore for monolith tins it has been calculated as zero and as 5% for U4/100 cores. This is a difficult error to calculate as samples can indeed stretch during sampling as well as compress, therefore a constant small compaction factor has been used. It is almost certainly negligible in comparison to the compaction undergone by the much of the sediment since deposition.

## Dating

The dates used in the sea level index point (SLIP) calculations are presented as the maximum intercept ranges. This differs from the methods used by Shennan and indeed prevalent within the sea level literature, where a median point is taken and presented on graphs with an error bar. The decision to use maximum intercept ranges was taken as this is considered to be a more mathematically 'correct' way of presenting a radiocarbon measurement which exists as a range in which all included years have an equal likelihood of being the actual year the dated organism died. The use of a median point can give a false impression.

## Water levels

Reference water levels have been calculated several ways. Modern MHWST is easily available and has been calculated by the Port of London Authority (PLA) and is on the web (www.portoflondon.co.uk) and in the tide tables for 2002 (PLA 2002). HAT is less easily measured and mean values have been calculated by the PLA taking all readings for 2001. This is obviously complicated by the times when the Thames Barrier was raised and these readings were taken out of the equation.

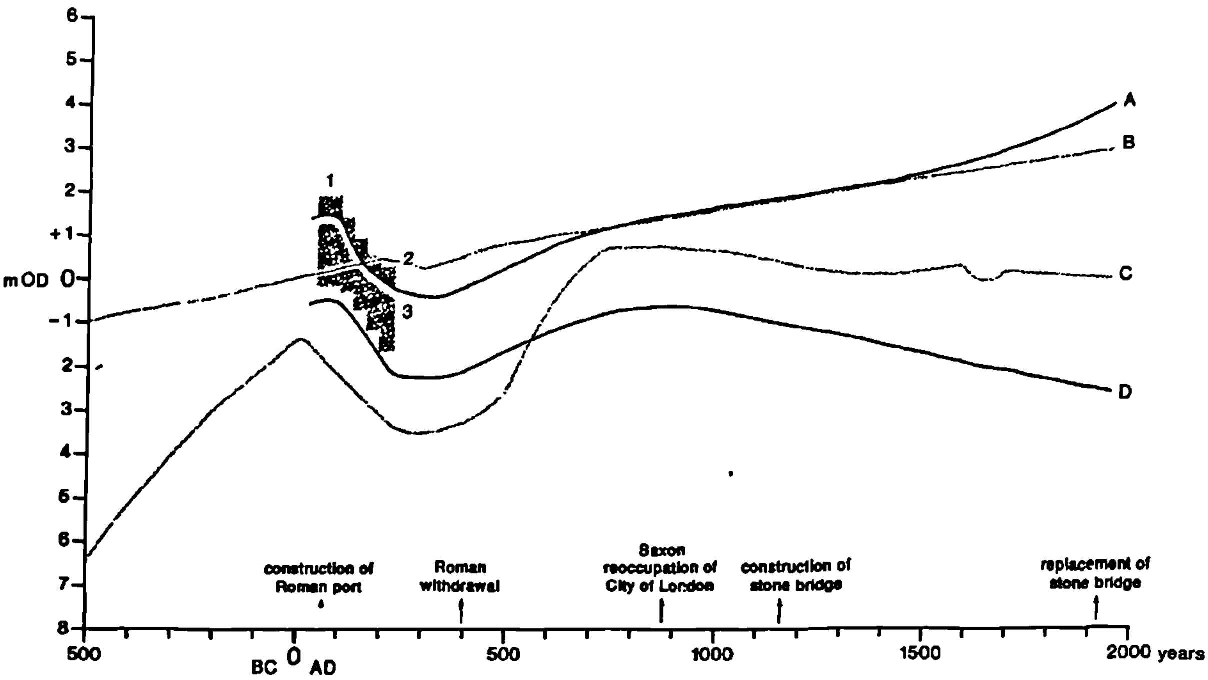
In addition to using contemporary water levels, an attempt has been made to calculate RSL by using ancient tide levels, extrapolated from archaeological evidence, for instance (Milne and Milne 1982, 61; Brigham 1990; Steedman et al. 1992; Brigham et al. 1996; Watson and Brigham 2001).

Calculations of medieval MHWST and HAT have mainly used the data calculated by Milne and Milne (1982, 61, figure 43) for the 14th century levels at Trig Lane in the

City of London and also the values obtained from other waterfront structures described in Chapter 11. These values have been extrapolated to the Blackfriars Bridge tide gauge station with no change in value, as Blackfriars is only 250m away from Trig Lane. Then the modern altitudinal differences in HAT and MHWST between the locations of the modern tide gauge stations have been extrapolated back to the medieval values. Although this involves several assumptions, namely that the calculation of the medieval tide levels are correct and that the modern variation in altitude along the estuary can be extrapolated back in time, this approach has been deemed the most feasible mechanism for looking at river level change and palaeotidal range.

Roman values are slightly more complex. Much more research has been undertaken on Roman water levels and reconstructions of MHWST are available throughout the period, which demonstrates more changeable levels than in the medieval period. This is most recently summarized in Watson et al. (2001, 26, figure 14) (see Figure 36) collated from extensive research on the subject (see Chapter 11, 11.3). In order to examine changes in tidal range, the sea level index points in this work have used MHWST for AD 50 (the foundation of the Roman port), AD 100, 200, 300 (lowest point) and 400 (approximately the end of the Roman period in Britain). The majority of sites considered by Watson et al. (2001) are located around London Bridge and downstream, therefore these figures have been tied to the Tower tide gauge. As for the medieval levels, the modern variation in MHWST at the various tide gauges has been used to reconstruct the Roman levels at the other tide gauge locations.

Calculations of Roman HAT have been undertaken across the period using all available published and unpublished data. The altitude of 0.8m OD for Roman Southwark calculated by Waddelove and Waddelove (1990) has been considered, but discarded as it appears to be based on less rigorous information than that presented elsewhere, detailed in Chapter 11. All calculated reference water levels (RWL) are based on the information presented there, and the graph of Watson and Brigham (2001). On the whole, the water levels have been tied to either the Blackfriars or Tower tide gauges, depending on which is closest to the key sites, i.e. Trig Lane to Blackfriars and Toppings Wharf to the Tower. As with the post-Roman data, modern variations in RWL between the tide gauges have been extrapolated back in order to calculate MSL at points along the estuary. The calculated levels are in Table 15 and 16 below.




1= Top of quays showing progressive drop in height
2= Top of foundations of Roman riverside wall
3= Late Roman ground levels at Summerton Way (Lakin et al. 1999)

A = MHW, City of London
B = MHWST, inner estuary
C = MSL, outer estuary (Devoy 1979)
D = MLW, City of London

Figure 36. Diagram of changes in water level, from Watson et al. (2001, 26, figure 14)

It is acknowledged that this approach is subject to a number of assumptions any of which could be inherently unsound, making these figures unreliable. First amongst these is tying the working surface of the quays to HAT. This is a good working principle, but is not necessarily true in all cases. The waterfronts built by centralized government are likely to have been more sturdily and efficiently built than those thrown up by the tenant. In the latter case, there may have been less attention paid to the occasional flood. It is, in fact, impossible to establish the exact indicative meaning of each quay and this is why the most likely estimate must be made in order to proceed with the analysis. A second problem comes with the structures themselves. In many cases they have survived complete, but this is not always the case. Some incomplete quays have been reconstructed and the altitude of the working surface estimated. This could, therefore, be providing misleading altitudinal data. Nevertheless, the altitudes are based on a number of examples and not solely incomplete ones. The next problem comes with the timing of events; dendrochronology is a good indicator; none better exists at present, but the question really is, what was the response rate of the population to river level change? If this was more than a year or so, then the fine-tuning of the chronological calculations will be at fault.

| Tide gauge station | HAT AD 50 | HAT AD 100 | HAT AD 20 | HAT AD 300 | HAT AD 400 | HAT AD 1000 | HAT AD 1400 | HAT 2001* |
|---|---|---|---|---|---|---|---|---|
| Blackfriars | 2.38 | 1.50 | 1.30 | 1.10 | 1.70 | 1.90 | 2.00 | 4.87 |
| Tower of London | 2.00 | 1.12 | 0.92 | 0.72 | 1.32 | 1.52 | 1.62 | 4.49 |
| North Woolwich | 2.30 | 1.42 | 1.22 | 1.02 | 1.62 | 1.82 | 1.92 | 4.79 |
| Dagenham | 2.23 | 1.35 | 1.15 | 0.95 | 1.55 | 1.77 | 1.87 | 4.72 |
| Greenhithe | 2.12 | 1.24 | 1.04 | 0.84 | 1.44 | 1.66 | 1.76 | 4.61 |
| Tilbury | 1.92 | 1.04 | 0.86 | 0.66 | 1.24 | 1.46 | 1.56 | 4.41 |

* Values for HAT were calculated by the PLA using all readings for 2001 and are presented as the mean value for each tide gauge

Table 15. Reference water levels (HAT) at some of the Thames tide gauge stations, both modern and 'ancient'. All values are in metres OD

| Tide gauge station | MHWST AD 50 | MHWST AD 100 | MHWST AD 200 | MHWST AD 300 | MHWST AD 400 | MHWST AD 1000 | MHWST AD 1400 | MHWST 2002 |
|---|---|---|---|---|---|---|---|---|
| Blackfriars | 1.35 | 0.05 | -0.15 | -0.35 | 0.25 | 1.6 | 1.75 | 3.85 |
| Tower of London | 1.4 | 0.1 | -0.1 | -0.3 | 0.3 | 1.22 | 1.37 | 3.9 |
| North Woolwich | 1.15 | -0.15 | -0.35 | -0.55 | 0.05 | 1.4 | 1.55 | 3.65 |
| Dagenham | 1.02 | -0.28 | -0.48 | -0.68 | -0.07 | 1.27 | 1.42 | 3.52 |
| Greenhithe | 0.90 | -0.40 | -0.60 | -0.80 | -0.19 | 1.15 | 1.3 | 3.4 |
| Tilbury | 0.66 | -0.52 | -0.72 | -0.92 | -0.31 | 1.03 | 1.18 | 3.28 |

Table 16. Reference water levels (MHWST) at some of the Thames tide gauge stations, both modern and 'ancient'. All values are in metres OD

Once the archaeological figures have been produced, further possibilities creep in. As mentioned above, there is the problem about using modern differences in tidal range along the estuary to apply to the archaeological periods. As it appears obvious that tidal range has changed over the millennia, it seems likely that differences in range along the estuary have also changed, although probably not in the same order of magnitude. Again, if the analysis is to proceed, then this assumption must be made, at least until tide level reconstruction can be undertaken along the estuary. There is, finally, the question of whether the data are too poorly resolved to be used. In comparison with conventional sea level index points, the answer is, probably not, as the inherent errors are still quite small and the data must be used in order to test the efficacy of this approach.

# Section II. Site data

## *Chapter 4. Wennington Marsh, A13 relief road, London Borough of Havering, RM15 (TQ 5425 8025).*

## 4.1 Introduction

### Site Location

The site (code WE-WM94, GLSMR 062566) is located on Wennington Marsh (1 on Figure 37), on the line of the A13 relief road (Thames Avenue) in the London Borough of Havering. The sampling site is *c.* 1km from the present course of the Thames opposite Erith (2 on Figure 37) and Crayford Ness (3 on Figure 37) and is approximately three kilometres from the border with Essex to the east. The area is open reclaimed marsh, to the west of the original line of the A13 road. Wennington Marsh is part of a landscape comprising Rainham Marsh (4 on Figure 37) to the west and Aveley Marsh (5 on Figure 37) to the southeast, with Rainham village (6 on Figure 37) and Aveley (7 on Figure 37) being the nearest settlements. This area was in the possession of the Ministry of Defence (MoD) as former training grounds and has remained undeveloped amidst the continued growth of the London urban sprawl. The sampling site is now located adjacent to the A13 diversion route, whilst Wennington Marsh as a whole remains largely untouched. Rainham Marsh has now been transferred to the RSPB as a protected nature reserve and Site of Special Scientific Interest (SSSI).

### Previous Research

Very little stratigraphic examination has been undertaken on Wennington Marsh. One piece of work looking at a stretch of the estuary was carried out in advance of the channel tunnel rail link (CTRL), which bisects the area (Bates 1999). It is based on all the geotechnical data amassed by the CTRL engineers. This analysis suggests the floodplain in this area consists of gravel (Shepperton Terrace) from below *c.* -8.0m OD and is overlain by clay silts and organic muds, sealed by one substantial peat deposit overlain by more silt clay, which extends up to the modern soil (Figure 38). Plans of the CTRL trace indicate that cores 121 and 18 (8 and 9 on Figure 37) are approximately 300 metres to the southeast and southwest of the Wennington site.

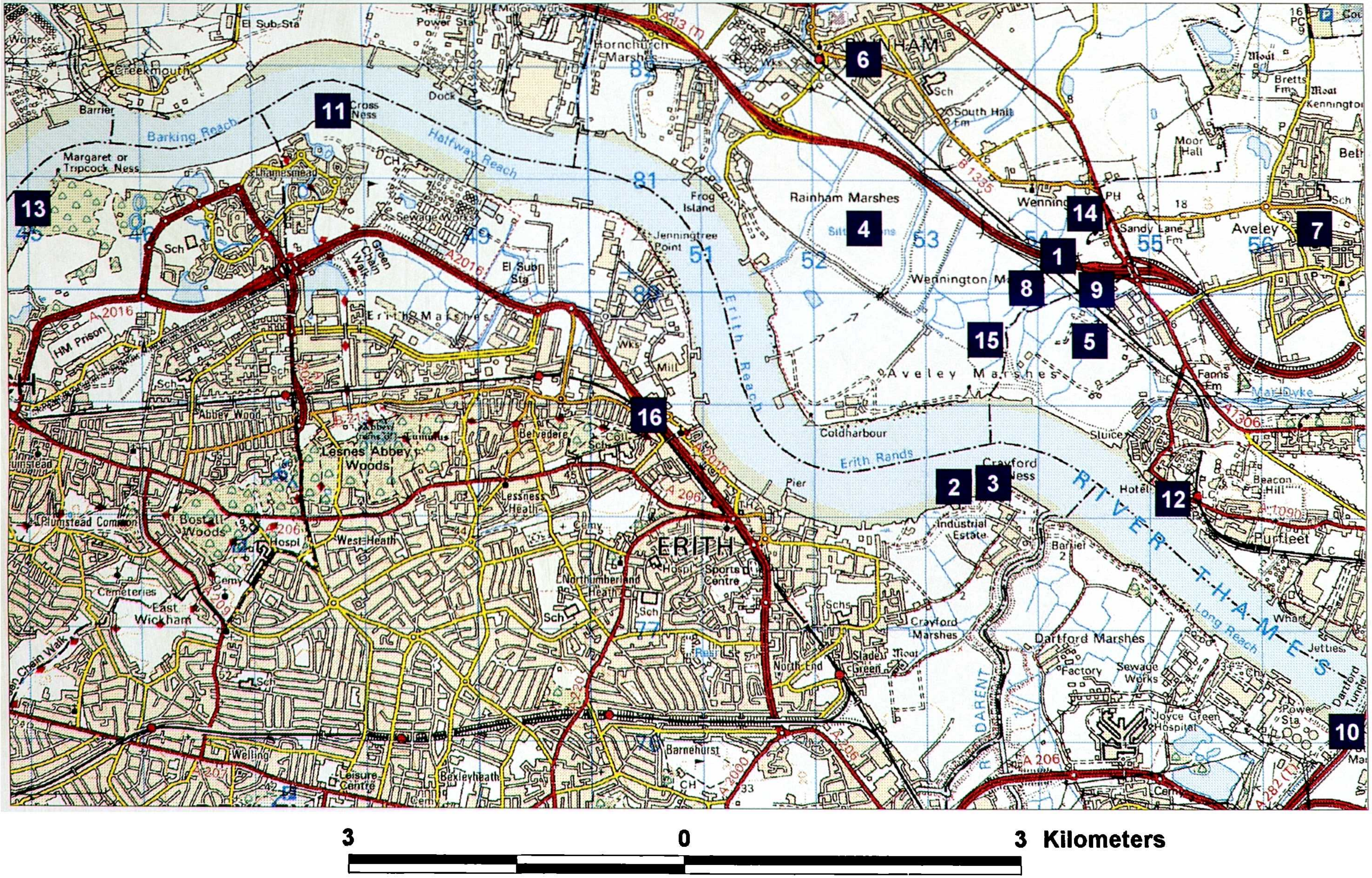



Figure 37. Location map of Wennington Marsh and other sites mentioned in this chapter

| No. | Sites | Eastings | Northings |
|---|---|---|---|
| 1 | Wennington Marsh | 5425 | 8025 |
| 2 | Erith foreshore | 5330 | 7820 |
| 3 | Crayford Ness | 5365 | 7828 |
| 4 | Rainham Marsh | 5250 | 8050 |
| 5 | Aveley Marsh | 5450 | 7950 |
| 6 | Rainham Village | 5250 | 8200 |
| 7 | Aveley | 5650 | 8050 |
| 8 | Channel Tunnel Rail core 121 | 5395 | 7995 |
| 9 | Channel Tunnel Rail core 18 | 5455 | 7995 |
| 10 | Dartford Tunnel | 5675 | 7600 |
| 11 | Crossness | 4780 | 8150 |
| 12 | Harrisons Wharf | 5525 | 7808 |
| 13 | Ring Ditch | 4500 | 8063 |
| 14 | Ring Ditch | 5448 | 8065 |
| 15 | Wennington Creek | 5360 | 7950 |
| 16 | Erith Spine Road | 5060 | 7880 |

Table 17. Sites shown on Figure 37

Previous examination of RSL change in this area was undertaken by Devoy (1977, 1979, 1980), and is discussed in Chapters 2, 11 and 12. Wennington Marsh falls within his sampling corridor, west of the Dartford Tunnel (10 on Figure 37) and east of the Crossness sites (11 on Figure 37), but is on the north side of the river. The core (Devoy 1979, figure 28a) from Harrisons Wharf (12 on Figure 37) in Purfleet, close to Wennington, indicates that if the Thames/Tilbury stratigraphic model is correct, a regressive sequence comparable with Tilbury III might be expected from between *c.* 5000 and 4000 radiocarbon years BP at this site (see Figure 39). The transgressive overlap to Thames III is not dated in this location. No other RSL analysis has been undertaken in this area.

There have been no modern archaeological interventions upon Wennington Marsh. Examination of the GLSMR shows a number of features, structures and artefacts recorded close by. The earliest of these include Mesolithic flint tools (GLSMR 060055, 060057), unfortunately not described in detail. Another prehistoric record is of a field system (GLSMR 060928), ascribed as prehistoric undated. Other interesting features are two ring ditches (GLSMR 061532/33, 13 and 14 on Figure 37) that were observed, on aerial photographs taken in 1976, as crop marks. These are very close to the sampling site and although undated, may be mid Bronze Age, which has implications for the nature of land use at this date, which equates with Tilbury IV. A less likely possibility is that they could be Saxon and have some relationship with another find noted close by, (bearing in mind the locations given with these find spots are often less than precise); a Saxon shield and metalwork thought to be associated with an inhumation (GLSMR 060056).

No Roman observations are noted close to the sampling site. There is some suggestion of a Saxon *burh*, or defended settlement in the area, presumably on the slightly higher and more well drained gravel terrace to the north of the sampling site. There are a number of records of medieval churches and medieval and post-medieval manor houses. There is also evidence for management of the marshes, with earthworks associated with post-medieval navigation of Wennington Creek (GLSMR 061061, 15 on Figure 37). This also includes wharf and wharf house remains (GLSMR 060928) and an 18$^{th}$ century dam associated with the Great Salting (GLSMR 061062).

The area never appears to have been densely occupied, with the medieval period seeming to be the most important with a series of contemporary churches and manor houses, similar to that seen across the river on the south at Erith (16 on Figure 37). This may reflect the usefulness of the marsh for grazing. Reclamation is thought to have begun relatively early, possibly before the Norman conquest of 1066; however, it seems likely that reclamation was carried out *ad hoc* in the medieval period by different landowners, many of whom are recorded as having large stock holdings in the Domesday book (Chandler 2001). It was only in the late medieval and post-medieval period that river defences were built, shown in legal statutes associated with construction and upkeep. However, the prehistoric information is also important, and it is interesting to note that Mesolithic communities used the area.

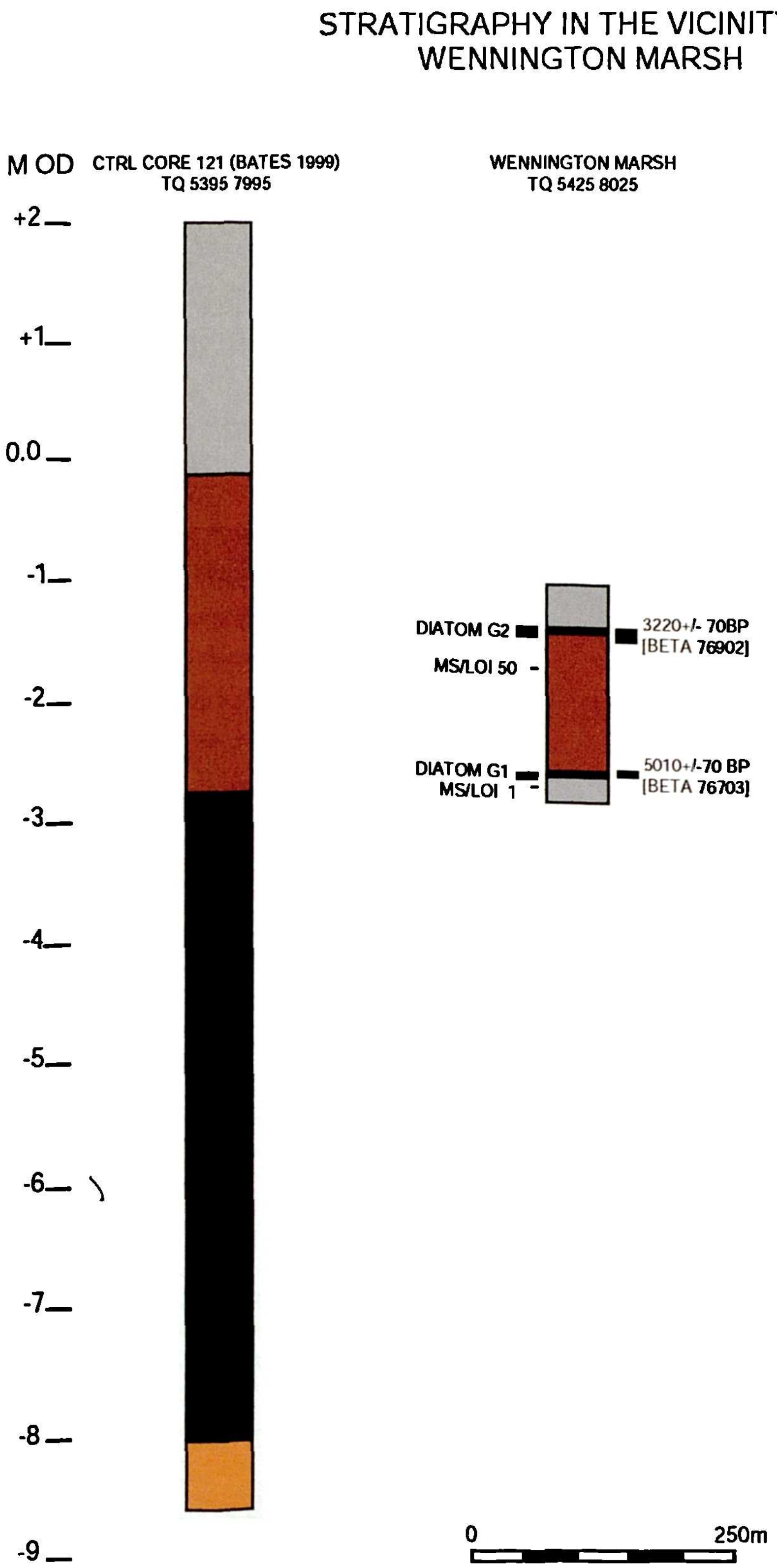



Figure 38. Stratigraphy in the vicinity of Wennington Marsh. See Figure 91 for key

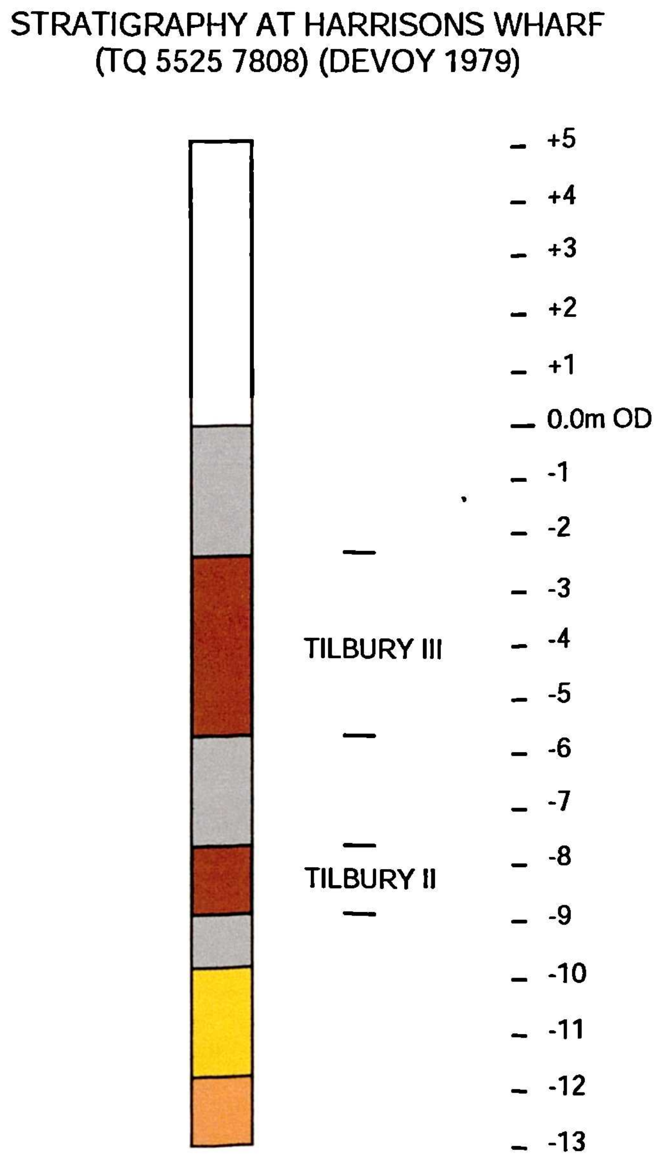



Figure 39. Harrisons Wharf sedimentary log from Devoy (1979, figure 28a).
See Figure 91 for key

## The Project

Excavation was undertaken under rescue conditions during construction work, initiated by the recovery of 20 trees, mainly *Taxus* (yew), from a peat deposit within a settlement trench being dug by the road contractors adjacent to the route. No physical traces of human activity were observed; however, all spoil had been machined from the trench so it was unlikely that anything would have been spotted. The road contractors only allowed a few hours of machine down time to recover material considered of archaeological interest, and therefore a degree of prioritization had to be employed. This did not allow for detailed examination of all sections for cut features or scanning the spoil heap for artefactual material.

Estuarine silt clay

Main peat horizon

Estuarine silt clay

Figure 40. Sampled section at Wennington Marsh (1m scale)

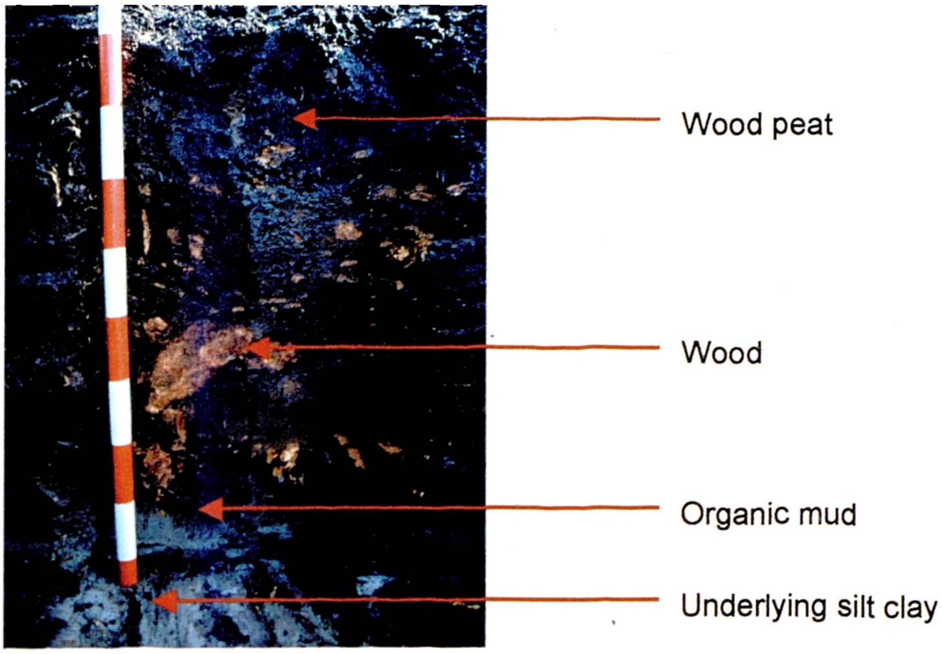



Figure 41. Detail of the underlying silt clay and wood peat in the sampled section at Wennington Marsh (1m scale)

Sampling was carried out on the west facing trench section (Figure 40), which was the only one that could be made safe. It was, nevertheless, representative of the general sequence revealed throughout the trench. Four monolith samples were collected, with a total depth of sequence of 1.65m. It was not possible to bottom the sequence to gravel. Fifteen bulk samples were collected adjacent to the monoliths, in 100mm spits and subsampled for radiocarbon and plant macrofossils (See Appendix 1, Table 37 and 1.3). The timbers were not sampled on the afternoon when the site was notified, but were recovered and laid safely to one side, some placed in drainage ditches, to be recorded and sampled the following day (see Figure 45, below). This was done in order to get as much information from the trench as possible in the limited time available. Furthermore, a chainsaw had to be procured as sampling *Taxus* using handsaws can take several hours (and saws) per trunk. The timber recording included general measurement and dendrochronology.

Following fieldwork, an assessment indicated that biological preservation was good and the stratigraphy was straightforward. The first (and still only) dendro date for prehistoric timber in London was also obtained, giving chronological control in the middle of the sequence. The lack of previous archaeological and palaeoecological research increased the significance of gaining good understanding of the depositional environment. On the basis of the following criteria, the site was selected for analysis in this thesis:

- *Clear sedimentary sequence*
- *Position in the Devoy study area but in an otherwise poorly researched location*
- *Good biological preservation with potential for environmental reconstruction and sea level analysis*

This section summarizes and interprets the data collected from this site whilst the raw data is in Appendix 1. The sedimentary sequence collected from Wennington can be divided into three main deposits; basal mineral, central organic and upper mineral deposits. There are transitional stratigraphic zones (organic muds) between these deposits and no suggestion of any eroded surfaces (see Figure 42).

## 4.2 The Sequence

The Shepperton Terrace was not reached here owing to water ingress and the time constraints upon sampling, but it has been identified close by on the route of the CTRL (Bates 1999 and see Figure 38 above). The lowest deposit (base -2.68m OD) was a finely sorted silt with traces of humified organic material (see Appendix 1, Table 34). The presence of iron staining may indicate a degree of sub-aerial weathering during deposition and suggests that although sedimentation was occurring under mainly aquatic conditions, there were periods of exposure. It seems possible that the degraded organics derived from either vegetation growing on such an exposed (or periodically exposed) surface, or the preserved fragments have been locally eroded and transported onto site. The deposit then fines up with increasing amounts of humified organic material (undifferentiated material with traces of reed and wood fragments). The decrease in particle size indicates a reduction in the velocity of flow, presumably as a result of the migration of the waterbody (presumably the Thames) away from the sampling site, or a relative drop in water levels at this location.

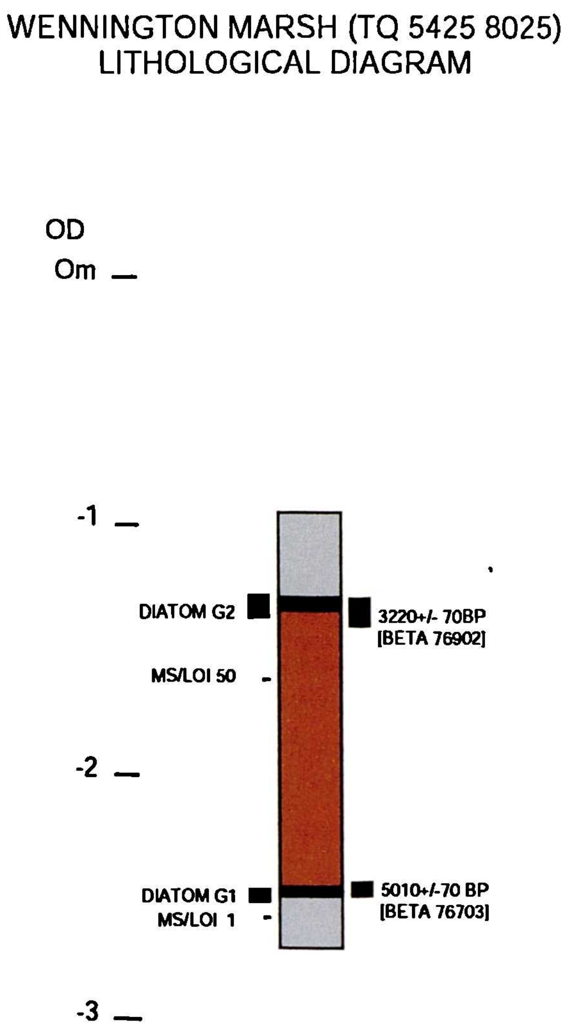



Figure 42. Wennington Marsh lithological diagram. See Figure 91 for key

Wennington Marsh diatom diagram

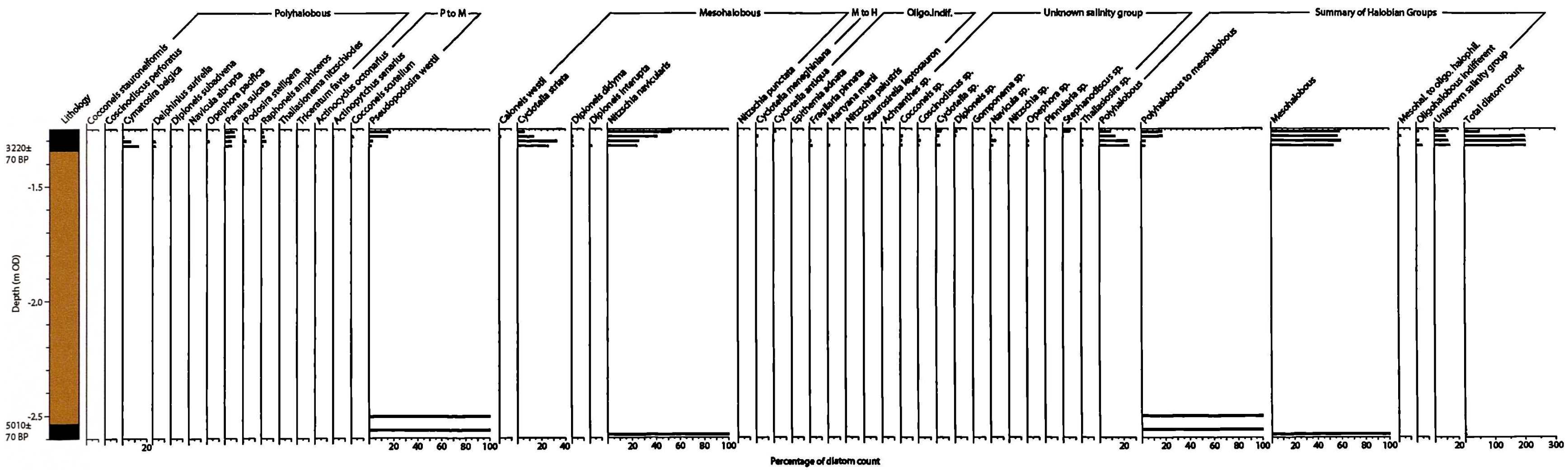
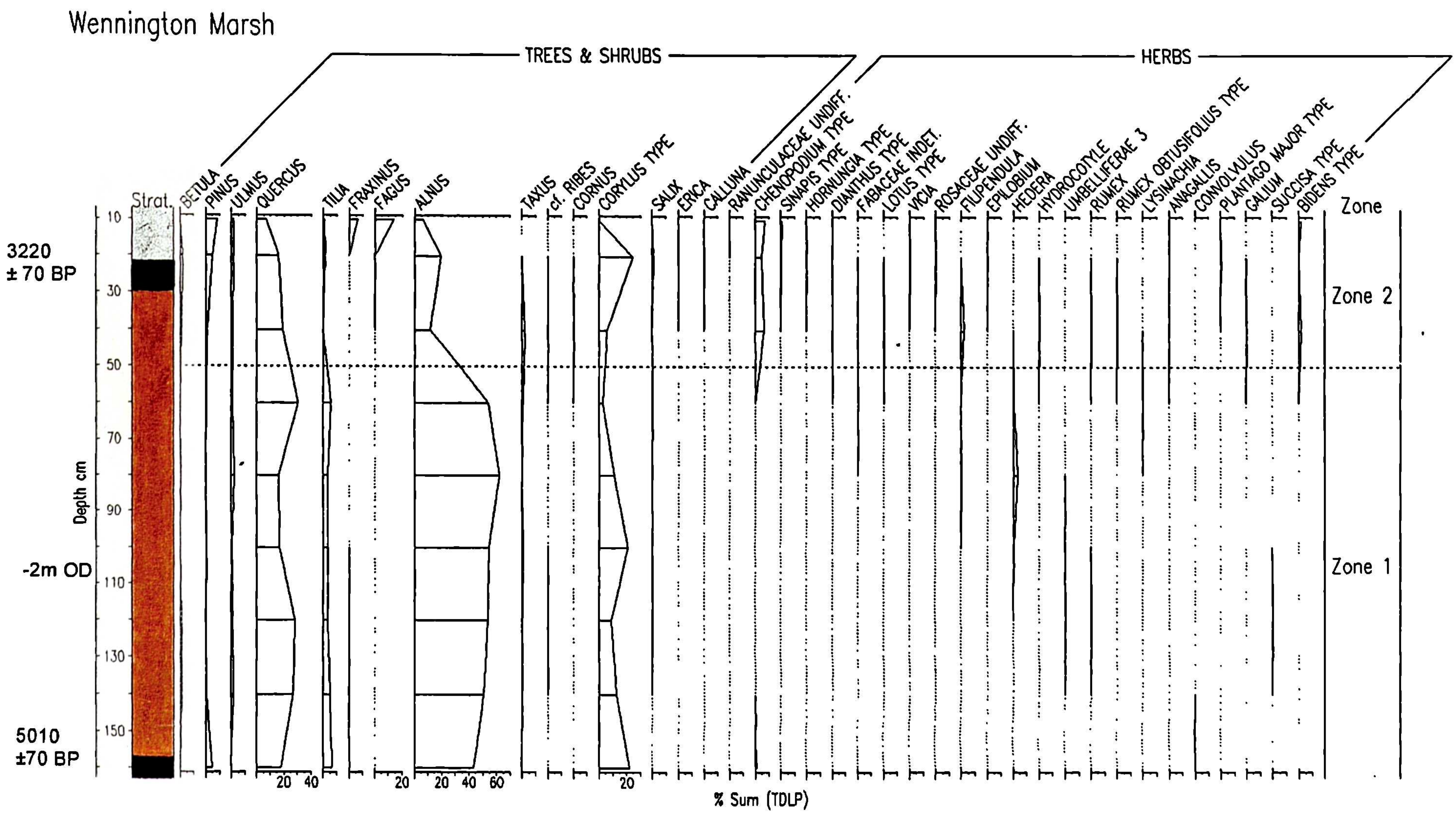


Figure 43. Wennington Marsh diatom diagram

Diatoms from the lower mineral deposits were poorly preserved and no full counts could be obtained (see Figure 43 and Appendix 1, Table 39). Species included *Pseudopodosira westii* and *Nitzschia navicularis*. Potentially this could indicate a very advanced case of differential preservation, and/or be an indication of estuarine conditions. Although this can only be discussed tentatively, the ecology of the species suggests the *Melosira (Paralia) sulcata* and *Navicula digito-radiata* var. *minima* groups of Vos and de Wolf (1993). These both indicate estuarine conditions commensurate with a large tidal channel and mudflats. No freshwater species were recovered here.

The sequence becomes a more fully organic mud above *c.* -2.5m OD; - a dark brown slightly degraded sediment with substantial fragments of herbaceous plant material and reeds dominating the base of the sequence at approximately 50% total organic carbon. Some woody fragments were present but it is only in the upper part of the stratum that wood becomes the dominant component, with the deposit reaching in excess of 80% total organic carbon. The lower contact of this organic deposit gave a radiocarbon date of 5010±70 BP (Beta 76903; 3960-3650 cal BC, -2.5m OD) (see Appendix 1, Table 37), showing that the major period of organic sedimentation began in the Early Neolithic. The pollen from the lower part of the peat shows the presence of large numbers of aquatic and marshy species including Cyperaceae (spike rush), *Sagittaria* (arrow head), *Typha latifolia* (great reedmace), *T. angustifolia* type (lesser reedmace), Hydrocotyle and *Sphagnum* (moss) (see Appendix 1, 1.3). Nevertheless, the overall assemblage is dominated by tree species such as *Quercus, Tilia, Fraxinus* (ash), *Alnus, Corylus avellana* type (hazel) and *Salix* (willow). This may suggest a mosaic of ecological types with a more local wetter alder carr environment and a background of mixed deciduous woodland to the north on the terrace edge. Initially this arboreal component may have been located close to, but not on site, which still appears to be a marsh environment forming the organic muds as a combination of decaying vegetation and mineral sediment, presumably transported by the river.


Wennington Marsh
TREES & SHRUBS
HERBS
BETULA
PINUS
ULMUS
QUERCUS
TILIA
FRAXINUS
FAGUS
ALNUS
TAXUS
cf. RIBES
CORNUS
CORYLUS TYPE
SALIX
ERICA
CALLUNA
RANUNCULACEAE UNDIFF.
CHENOPODIUM TYPE
SINAPIS TYPE
HORNUNGIA TYPE
DIANTHUS TYPE
FABACEAE INDET.
LOTUS TYPE
VICIA
ROSACEAE UNDIFF.
FILIPENDULA
EPILOBIUM
HEDERA
HYDROCOTYLE
UMBELLIFERAE 3
RUMEX
RUMEX OBTUSIFOLIUS TYPE
LYSIMACHIA
ANAGALLIS
CONVOLVULUS
PLANTAGO MAJOR TYPE
GALIUM
SUCCISA TYPE
BIDENS TYPE
Zone
Zone 2
Zone 1
Strat.
Depth cm
3220
± 70 BP
-2m OD
5010
±70 BP
% Sum (TDLP)

Wennington Cont.

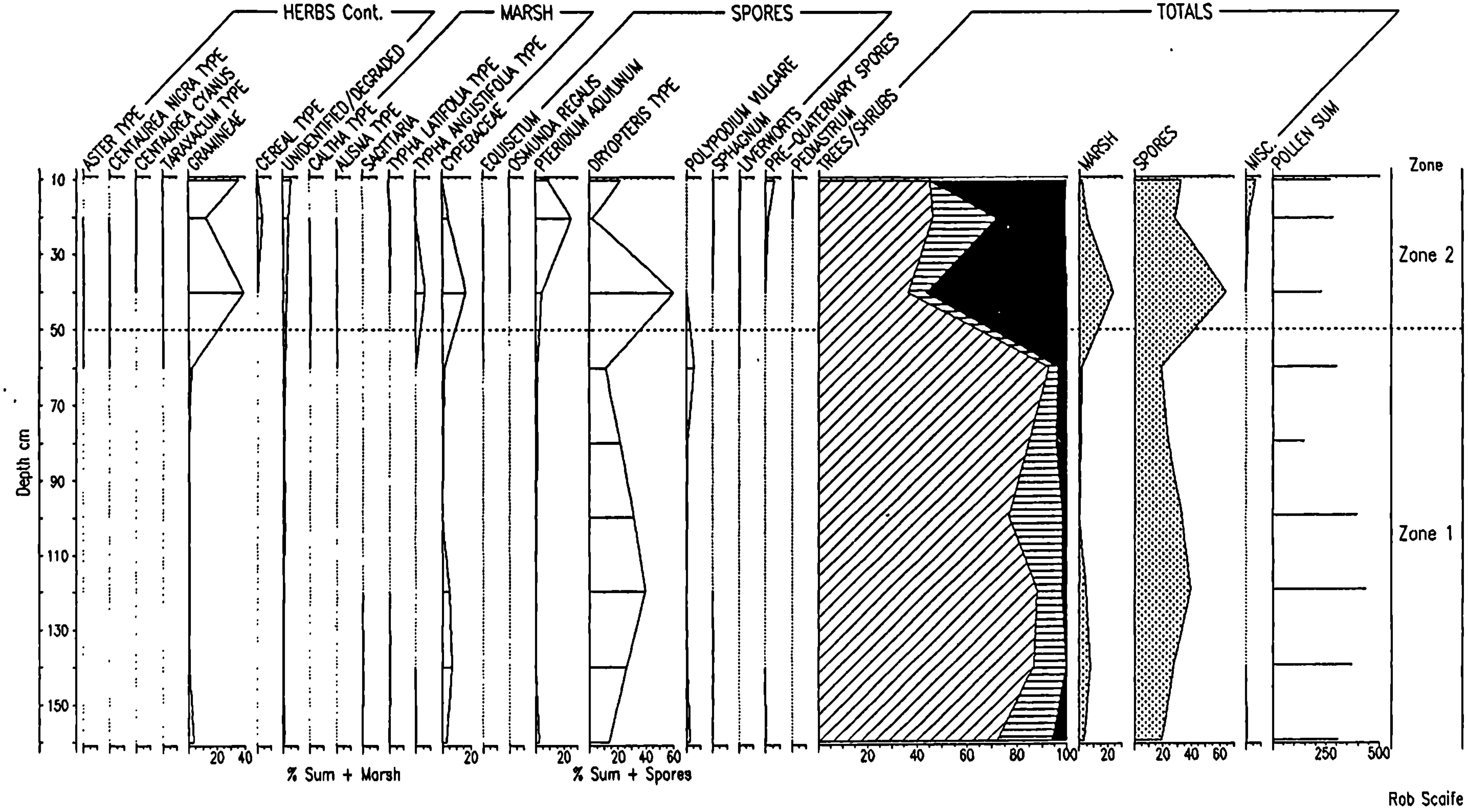



Figure 44. Wennington Marsh pollen diagram (by Dr. Rob Scaife)

The plant macro-fossils in the lower part of the peat consisted of a limited assemblage of species including *Rubus* (berry/bramble), Cyperaceae, *Carex* (sedge), *Ranunculus* subgen *Batrachium* (buttercup), *Solanum dulcamera* (bittersweet/woody nightshade) and Umbelliferae (carrot family) which would tend to confirm the suggestion of a locally wet environment (see Appendix 1, 1.3). There is no firm evidence of any salt water species within this group, and it seems therefore that the sampled sediments were significantly above the tidal margins, indicating a negative tendency of sea level movement. A further sample from slightly higher up, at *c.* -2.3m OD showed that preservation of macrofossils had deteriorated, with only *Typha* sp. identifiable.

A wood peat containing large numbers of trees indicating a continuation of the negative sea level tendency superseded the organic mud above *c.* -2.0m OD. The trunks (see Figure 45) were recorded and details may be found in Appendix 1, Table 40. However, species diversity is restricted and does not match the initial deciduous woodland community shown in the lower samples. The tree remains were almost all *Taxus* with a few *Quercus*. The presence of *Taxus* in lowland river valley peat beds is extremely rare; this appears to be an extinct form of wetland (Godwin 1956, 274) and may be at least partly a result of human selection owing to the toxicity of the species. The community appears to have thrived for some time; the ring sequences did not show any sign of stress and demonstrated the trees were living in excess of several hundred years as well as achieving very good heights (up to 12 metres). Archaic yews are known from across and further up the Thames (Seel 2001) and have also been recorded in the Cambridge fens, erroneously in many cases as *Quercus* (see Godwin 1956, 9) and also in Irish bogs. Godwin indicates that the species can survive quite well on fen peat and indeed many of the records come from Bronze Age horizons; he ascribes this to marine retrogression and dryness, both of which are beneficial to this species (Godwin 1935). Yews have been found by Thames antiquarians, including Spurrell (1885, 1889) and Samuel Pepys (Matthews 1972).

Figure 45. Some of the *Taxus* trunks from Wennington Marsh (1m scale)

This woody peat persists to *c.* -1.5m OD, although the deposit becomes increasingly humified. Pollen evidence from this level indicates dominance of woodland species, including *Quercus, Tilia, Alnus* and *Corylus avellana*. *Taxus* is recorded in low frequencies, but there is a wider problem with recognition/preservation of this pollen type within peat and lake muds (Godwin 1956, 275). Other taxa present include *Betula* (birch), *Pinus* (pine), *Ulmus* (elm) and *Salix*. The plant macrofossils also suggest a degree of wetness with sedges, duckweed and *Ranunculus* subgen *Batrachium* and the mosses *Neckera crispa* and *Eurynchium* cf. *striatum,* both of which can be found growing in wet woodland (Watson 1981). A dendrochronological date was obtained from one of the oaks; no bark was present, but thirteen sapwood rings were. The measurement corresponded with the period 2262-2139 cal BC (see Appendix 1, 1.3), and the death date of the tree could be just a few years after 2139 cal BC or as late as 2097 cal BC (all Early Bronze Age dates) on the basis of sapwood estimates (Hillam 1987).

The peat bed becomes even more humified towards -1.32m OD; very little identifiable material was recovered from within it; furthermore, there is a small proportion of mineral sediment within this upper part of the organic sequence. The sediment becomes much more mineral dominated from this point, dropping to *c.* 10% total organic carbon with a small transitional deposit of organic mud and a gradual (uneroded) change from almost entirely unidentifiable organic material to a grey brown (following rapid oxidization) silt clay, with some sand content and occasional fragments of mollusc shell. Sampling ceased here owing to contamination from modern overburden. A radiocarbon measurement of 3220±70 BP (Beta 76902; 1680-1320 cal BC, -1.3m OD) was obtained at the upper peat contact.

Pollen from the top of the peat and into the silty clay shows a significant reduction in the woodland cover and also the alder carr, with a corresponding rise in herbs including Poaceae (grass family), Cyperaceae and Chenopodiaceae (goosefoots). Plant macrofossils confirm the appearance of Poaceae, and also include *R.* subgen. *Batrachium,* sedge, *Juncus* (rush) and *Typha.* There could be several explanations for the replacement of the wood peat by a more herb rich environment; a rising watertable and increasing salinity may have made continued woodland development untenable leading to a progression towards a more marsh-based environment. Furthermore, human interference through deforestation may have led to increased run-off into the floodplain. There is no direct evidence for people acting as agents of deforestation within this sequence, but it is a well-known phenomenon in the London Thames in the early Bronze Age (Greig 1992). The rising watertable seems to be confirmed with the appearance of clay and silt within the organic facies, indicating that the site is now being inundated; an apparent positive sea level tendency on the basis of the biostratigraphy and the change from organic to inorganic sedimentation.

The diatom assemblages across this transitional zone (*c.* -1.3m OD) are dominated by *Cyclotella striata, Cymatosira belgica* and *Paralia sulcata. Nitzschia navicularis* is also present in large numbers, and these species indicate that the site was in an area of intertidal mud flats (Zong 1997; 1998). This pattern is reinforced in sample 8 where *N. navicularis* becomes dominant (50% of the total valve count), with a corresponding drop in channel species such as *C. striata* but an increase of *P. sulcata.* The final sample from the upper silty clay had a low valve concentration and a low count but on the basis of the limited assemblage, an extrapolation suggests that the pattern is generally similar to that of sample 8, with a likely continuation of mud flat and potentially low marsh development.

## 4.3 Site Summary

The sedimentary sequence and biostratigraphy (see Figure 46) indicate that this part of Wennington Marsh has been subject to inundation by the Thames for (at least) two phases of its Holocene history. The earliest deposits unfortunately, could not be sampled; however, by the Late Mesolithic, tidal waters were depositing fine-grained sediment on site, possibly on intertidal mudflats or tidal channels. From *c.* 3800 cal BC (5000 radiocarbon years BP), the site was subject to a protracted negative sea level tendency, as wetlands flourished for several thousand years. Therefore, it must be considered that from *c.* 5000 BP, either there was a decrease in the rate of river level rise or an actual drop in relative river levels. Previously published data (Long et al. 2000; Sidell et al. 2000), indicates a widespread wetland expansion from other sites in the estuary, from slightly before this date, which is not considered to be associated with an actual drop in RSL, but rather with a deceleration in the rate of RSL rise.

The wood peat takes an unusual form on Wennington Marsh by being dominated by *Taxus.* Peat formed slowly, probably under conditions of reduced RSL rise. If the tree-ring date is taken into account, it appears that the first half metre of peat took between approximately 1600 and 1900 calendar years to form, although undoubtedly the peat has been compressed. The upper radiocarbon measurement indicates that the upper 0.7m or so of peat took only between 400 and 750 calendar years to form, and was inundated in the Middle Bronze Age. This suggests an increase in the speed of peat formation perhaps driven by increased waterlogging consequent to the positive sea level tendency that culminated in the inundation of the site by estuarine waters. The lower deposits may have compressed more, owing to the weight of overburden, but it is likely that the substantial tree inclusions will have restricted compression.

It seems likely that the change from the wood peat to the more herbaceous peat marks the reversal of this tendency and gives a date for the beginnings of estuary re-expansion. It is not absolutely dated in the sequence, but must have occurred subsequent to the formation of the *Taxus* woodland (associated with which is the dendro date of c. 2100 cal BC) and before 3220±70 BP, (1682-1320 cal BC) when the peat was finally submerged. During this period, approximately 0.7m of peat was deposited, indicating more rapid peat growth than previously. If this was forming under conditions of rising water levels, it confirms a faster rate of rise than during the earlier phase of peat formation. This is, nevertheless, likely to have been complicated by factors such as increased run-off and waterlogging (see Waller 1994b).

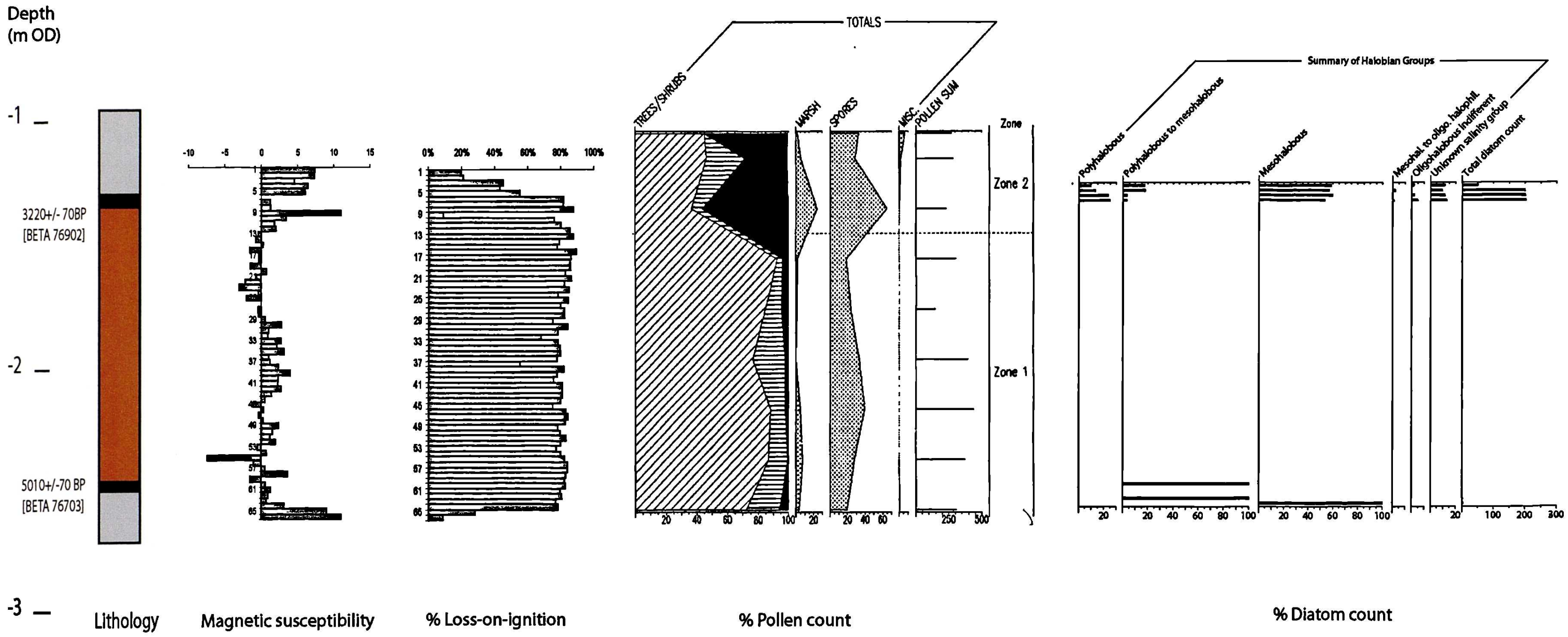



Figure 46. Wennington Marsh summary diagram

# *Chapter 5. Voyagers Quay, Copperfield Road, London Borough of Bexley, SE28 (TQ 4730 8130)*

## 5.1 Introduction

### Site Location

The site (code CPP96, GLSMR 071391) is located at Voyagers Quay (1 in Figure 47), Copperfield Road on the Thamesmead North estate (2 in Figure 47) in the London Borough of Bexley. It is now bounded to the north (approximately 100m away) by the River Thames and is slightly to the west of Cross Ness Point (3 in Figure 47). Castilion Primary School is on the western edge of the site and the Crossway to the south. The area was previously wasteland with some stands of salt marsh close to the river.

### Previous Research

Spurrell (1885) noted part of an extensive yew forest locally. He also observed yew trees at Crossness, some in excess of 450mm in diameter, and identifies these forests as indicating '*long periods of freedom from the tide*' (Spurrell 1885, 270). He subsequently (1889) described a section at Crossness, which he states is essentially the same as those on the north bank of the Thames. He found the gravel to be variable in grain size and often with oak within it. The gravel was generally sealed by mollusc rich sand, including *Hydrobia* sp., which he suggests indicates brackish waters here prior to the peat formation. A beaver was noticed in the forest peat, lying under a large tree. The peat was sealed by tidal clay, containing large amounts of *Scrobicularia* shells and *Phragmites.* Spurrell identifies a second, higher peat horizon, also containing many trees, with yew being more dominant in this horizon than in the lower one, which was dominated by alder and ash.

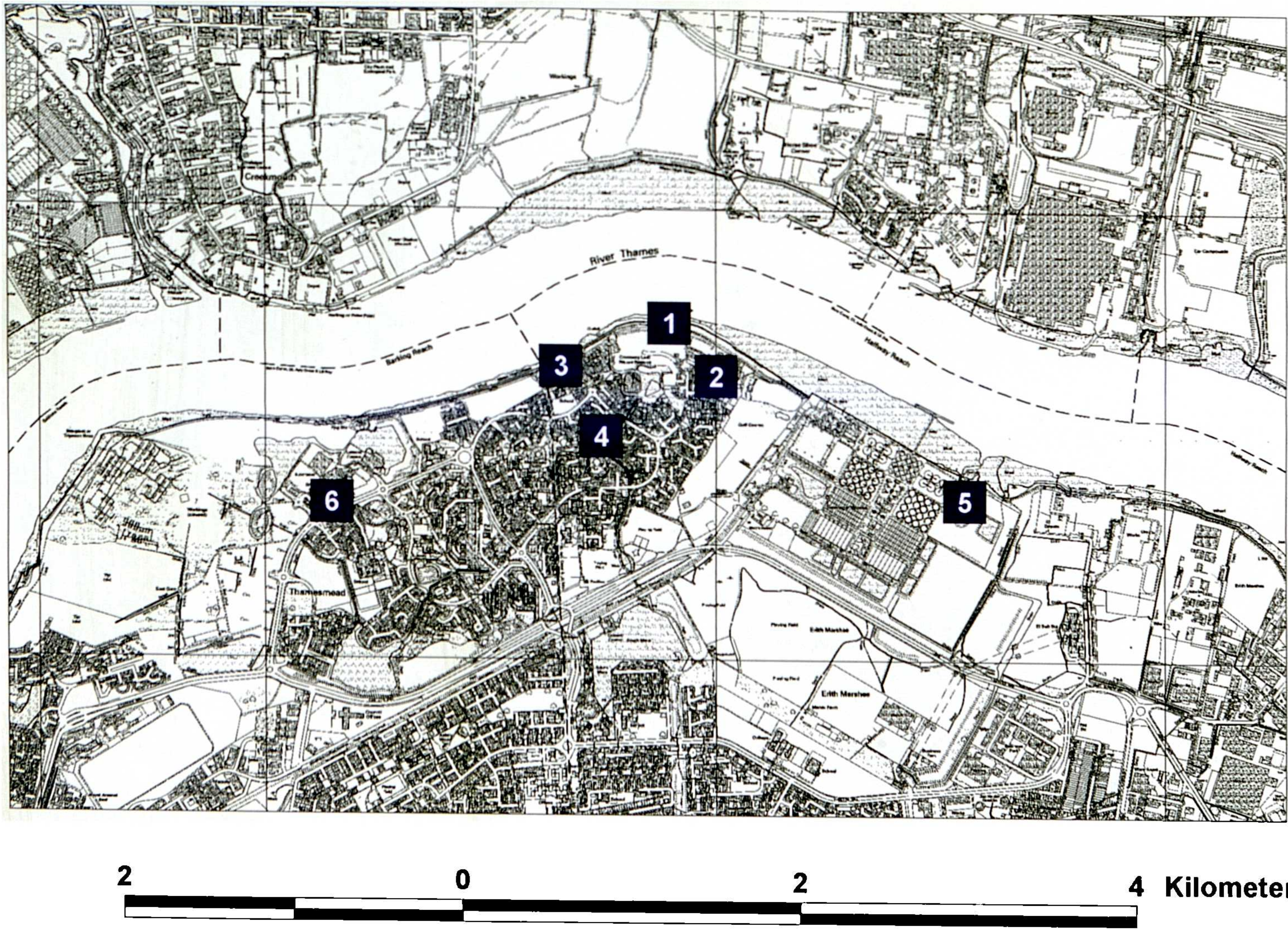



Figure 47. Location map of Voyagers Quay and other sites mentioned in this chapter

| No. | Sites | Eastings | Northings |
|---|---|---|---|
| 1 | Voyagers Quay | 4730 | 8130 |
| 2 | Thamesmead North Estate | 4750 | 8100 |
| 3 | Cross Ness Point | 4780 | 8150 |
| 4 | Summerton Way | 4800 | 8128 |
| 5 | Cross Ness sewage plant | 4910 | 8076 |
| 6 | Aldi store | 4630 | 8070 |

Table 18. Sites shown on Figure 47

Devoy also described stratigraphy from very close to the present Voyagers Quay (Devoy 1979), 370) with his cores 79, 80, and 81 (Devoy 1979, figure 11) located relatively close to the present site (see Figure 48). These show a variable stratigraphy on the south-north alignment, with gravel deepest to the south at approximately -8.0m OD, rising to nearly -6.0m OD in core 81. The gravel is overlain by silt clay away from the river and a silty sand closer by. In core 79, peat forms from *c.* -5.0m OD, but is not recorded in the other cores below -3.5m OD. It persists in these locations to -1.5m OD whilst it is not present above *c.* -3.5m OD in core 79. Devoy (1979) ascribed the peat to his Tilbury III phase. The peats are all sealed under further silt clay.

A geotechnical survey carried out at Voyagers Quay during exploratory works encountered organic clays interdigitating with several peat strata above silt clays and the terrace gravel. A survey of nearby Summerton Way, Cross Ness Point (GLSMR 071526) (4 in Figure 47) showed the stratigraphy to the east of Voyagers Quay to consist of laminated peat and organic mud (upper surface at between -1.3 and -1.9m OD, base below -3.0m OD), with a north-south palaeochannel cutting through this. The peat is thought to have formed in an alder carr and the upper surface was radiocarbon dated to 2850±70 BP (Beta 108101; 1220-830 cal BC, *c.* -1.5m OD) to the Late Bronze/Early Iron Age (Lakin 1999). Freshwater muds recorded up to -0.7m OD sealed it. Above this, a terrestrial surface developed, upon which Roman archaeology was recovered. This was sealed at -0.4m OD by estuarine muds containing Late Roman pottery (see Figure 48).

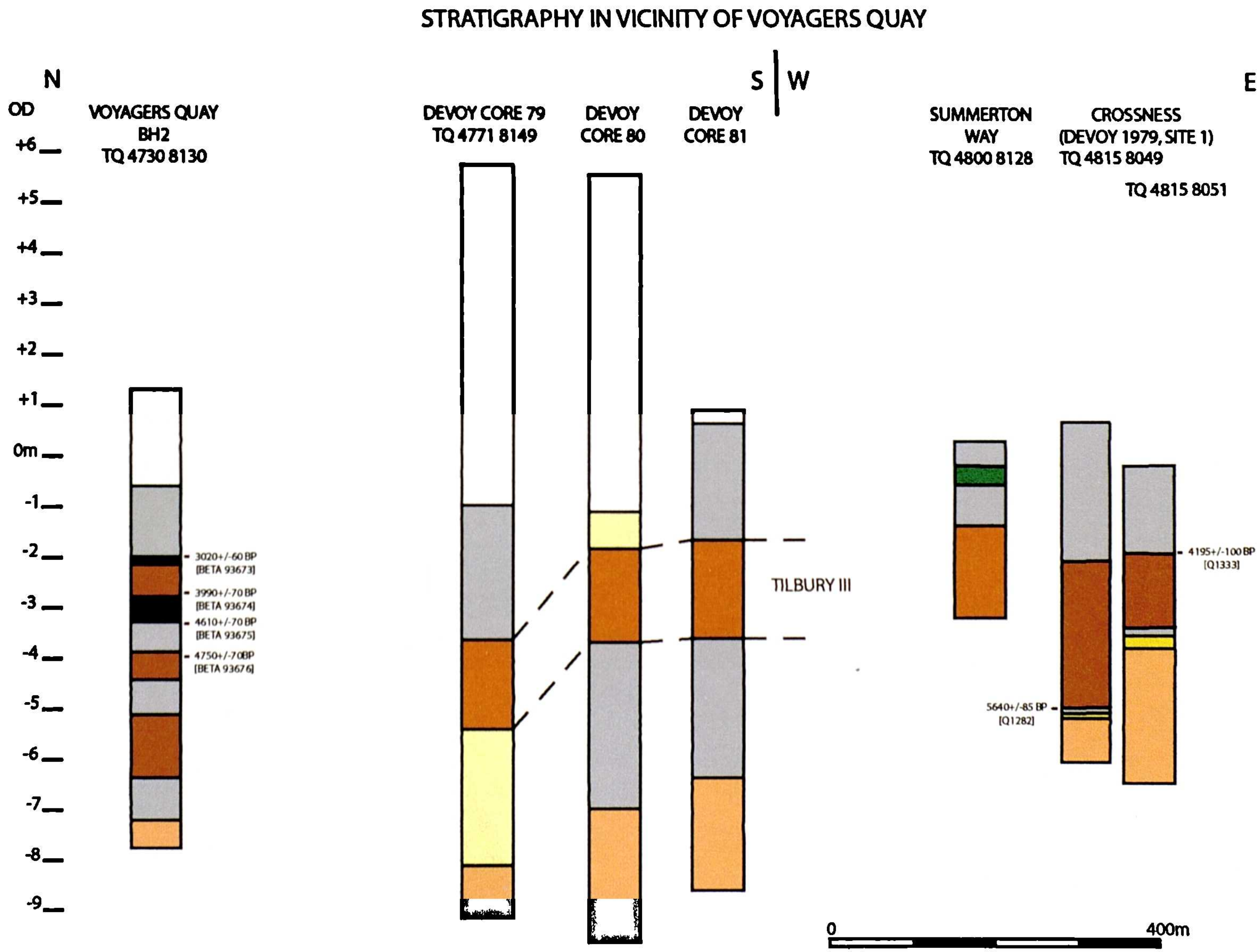
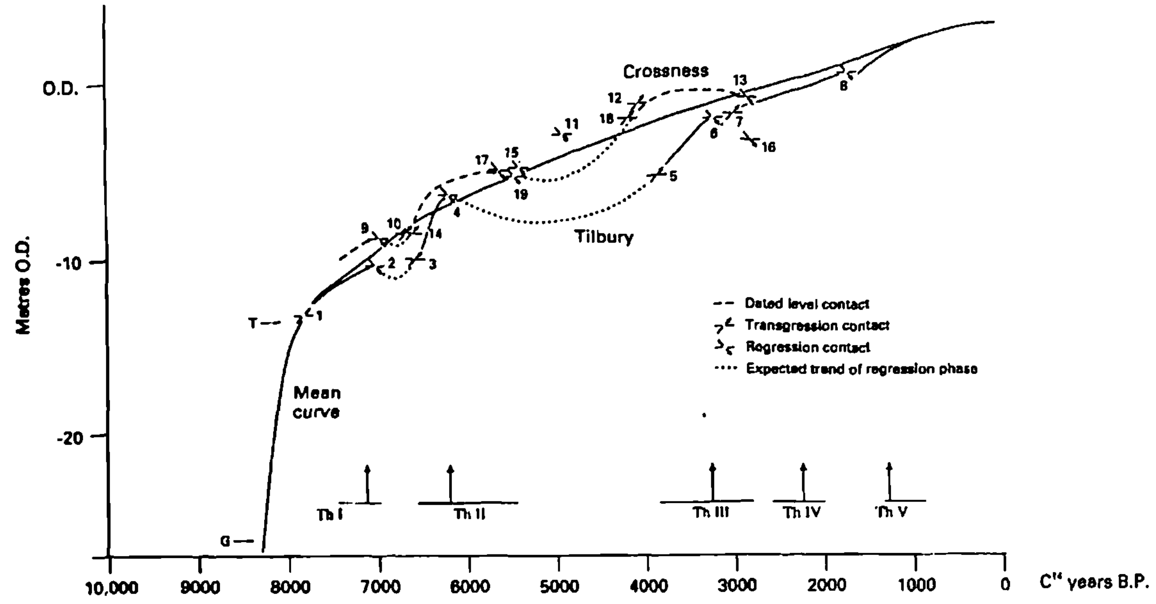



Figure 48. Stratigraphy in the vicinity of Voyagers Quay, after Devoy (1979) and Lakin (1999)

Work at the Cross Ness sewage plant (Pine 1994, 5 on Figure 47) demonstrated a sequence of sandy silts sealed by organic muds (with an estuarine signal in the diatom record) with two phases of organic formation (alder carr with subsequent salt marsh development at *c.* -1.0m OD). The thickness of each deposit was variable across the site. Organic muds lay between the two peat horizons whilst the upper peat was overlain by mineral sediment. The Aldi store site to the west of Voyagers Quay, (GLSMR 071873, 6 on Figure 47) proved the Shepperton Terrace below -8.0m OD, which was overlain by mineral sediment, a large peat deposit (with a thin lower peat in some places) and further silt, probably (although not confirmed) of estuarine origin. The onset of peat formation was dated to 6290±80 BP (Beta 120215, 5405-5050 cal BC) and it was sealed at 2810±60 BP (Beta 12012, 1120-820 cal BC, Sidell 1998).

The sampling site is close to Devoy's (1979) site 1 at Crossness/Thamesmead (see Figure 48). He documents a suite of boreholes across Plumstead Marsh, showing the surface of the gravel at varying depths from *c.* -2.5m OD to *c.* -7.5m OD, overlain by silts and rather variable peats, ascribed to Tilbury III (Devoy 1979, figure 9). The peat forms from *c.* -5.5m OD to *c.* -2.0m OD, and is sealed at altitudes of *c.* -4.0m OD to *c.* +0.5m OD. The boreholes on the eastern side of the site ('Crossness' and 'Erith Marshes') show gravel surfaces between -9.51m OD and *c.* - 4.0m OD with Tilbury II directly above the gravel (in most places). A clay silt is present above Tilbury II of variable thickness, between 5 and 0.5m. Tilbury III is absent in places but where present is similarly variable in thickness. The summary diagram (Devoy 1979, figure 28) shows the sequence at this site to consist of gravel between *c.* - 5.5 and -4.5m OD, overlain by a thin sequence (<0.5m) of Thames II which is in turn sealed by less than 2m of Tilbury III on the eastern side of the site, and by approximately 3m on the western side, where the gravel is lower.

A radiocarbon measurement of 5640±75 BP (Q-1282; 4690-4340 cal BC) was obtained from the base of the Tilbury III deposit and 4195±100 BP (Q-1333; 3020-2490 cal BC) was recorded for the contact at the top of Tilbury III on the eastern side of the site. On the sea level curve for the Thames proposed by Devoy (1979, figure 29, curve 2), the lower date is taken as an index point (number 17) of a regressive contact with a consequent (slight) drop in RSL at this date. The upper date (number 18) is taken as a transgressive contact reflecting an upward movement of sea level before and after this date. The curve between points 17 and 18 is only dotted in. This line suggests that the decrease in RSL was minor and occurred between *c.* 5500 BP and *c.* 5000 BP when it began rising again. This contrasts with the curve for Tilbury (Devoy 1979, figure 29, curve 1, shown below, Figure 49) where the drop begins before 6000 BP but the subsequent rise starts concurrently with that represented on curve 2.




Relative sea-level curves for the inner Thames estuary. Curve 1 is from Tilbury. Curve 2 is from Crossness, Stone Marsh, Dartford Tunnel and Broadness Marsh. Points 1-8 are from The World's End borehole (point 8 is a 'pollen date'). Points 9 13 are from Stone Marsh. Points 14-16 are from Broadness Marsh. Points 17 and 18 are from Crossness. Point 19 is from the Dartford Tunnel. The Isle of Grain date is represented by G.

Figure 49. RSL curve from Devoy (1979, figure 29)

Limited consideration of RSL movement was incorporated into the Summerton Way publication (Lakin 1999). This analysis was based mainly on the relative location of the archaeological horizons within the stratigraphy at this site. The Roman deposits were sited on land that is thought to have been in the Thames estuary during the Iron Age. The land then became part of the foreshore and finally fully terrestrial with the development of a palaeosol. This may have been caused by fluctuation in water levels rather than channel migration away from the site. MHW was calculated at or below approximately -1.0m OD in the Early Roman period here. The transgressive overlap at -0.4m, dated by ceramic typology to the 5th century AD was considered a reliable sea level index point (Lakin 1999).

There is limited archaeological evidence from the area, probably due to the restricted research undertaken to date rather than true evidence of absence. Isolated finds have been made along the river, including a Mesolithic bone awl (GLSMR 070514) and a Mesolithic axe (GLSMR 110052). Settlement evidence comes from Summerton Way, where Roman field systems, agricultural infrastructure and the remains of ceramic production were found (Lakin 1999). Spurrell (1885, 1889) noted substantial amounts ('*a couple of cartloads*') of Roman debris at Crossness (pottery, building material, food waste, *mortaria*, a grinding stone and a timber platform close to a modern stream) approximately 3m below surface (*c.* +1.5m OD) on a mossy peat surface. He concludes that the Roman occupation here was at a time of a depression in the estuary.

## The Project

Two boreholes were drilled in March 1996 using a shell and auger cable percussion rig as part of a conventional archaeological evaluation under a planning condition prior to the site being developed (see Figure 50). U4/100 samples were collected from all undisturbed sediment, sealed and taken to the Museum of London. A preliminary scan of the samples and selected subsamples split from the U4 samples was undertaken to establish the potential of the site. This assessment indicated a variable sequence between the two boreholes with the presence of organic muds, Neolithic/Bronze Age peats and mineral sediment over the Shepperton Terrace (see Figure 51). Several diatom and pollen slides were also prepared and scanned, indicating that biological preservation was reasonable.

Following this scan, the site was selected for analysis in this thesis on the basis of:

- *The geographical location close to the modern course of the Thames and at the western edge of the Devoy (1979) study area*
- *Reasonable biological preservation*
- *Potential to examine mid-Holocene sea level change*

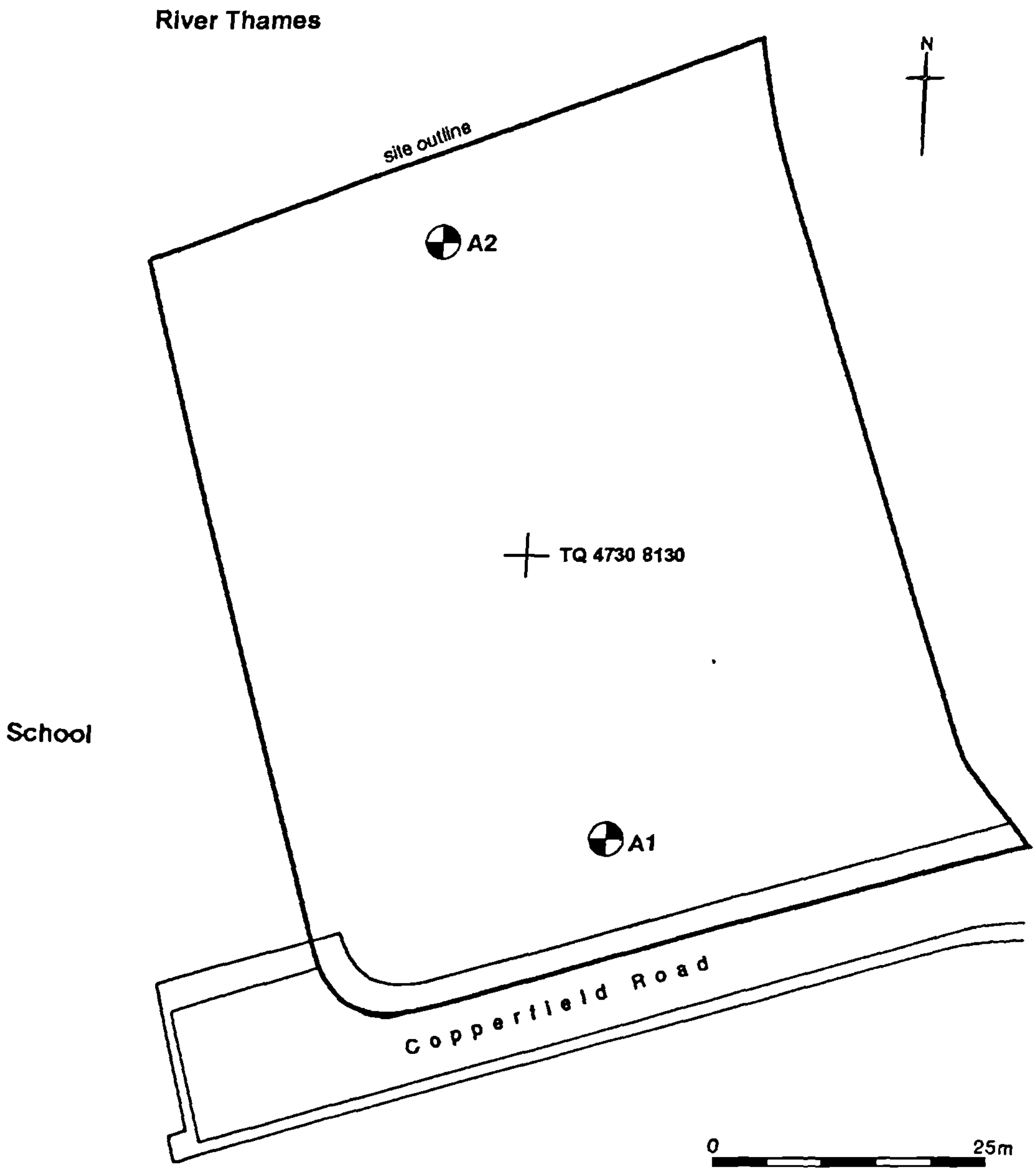
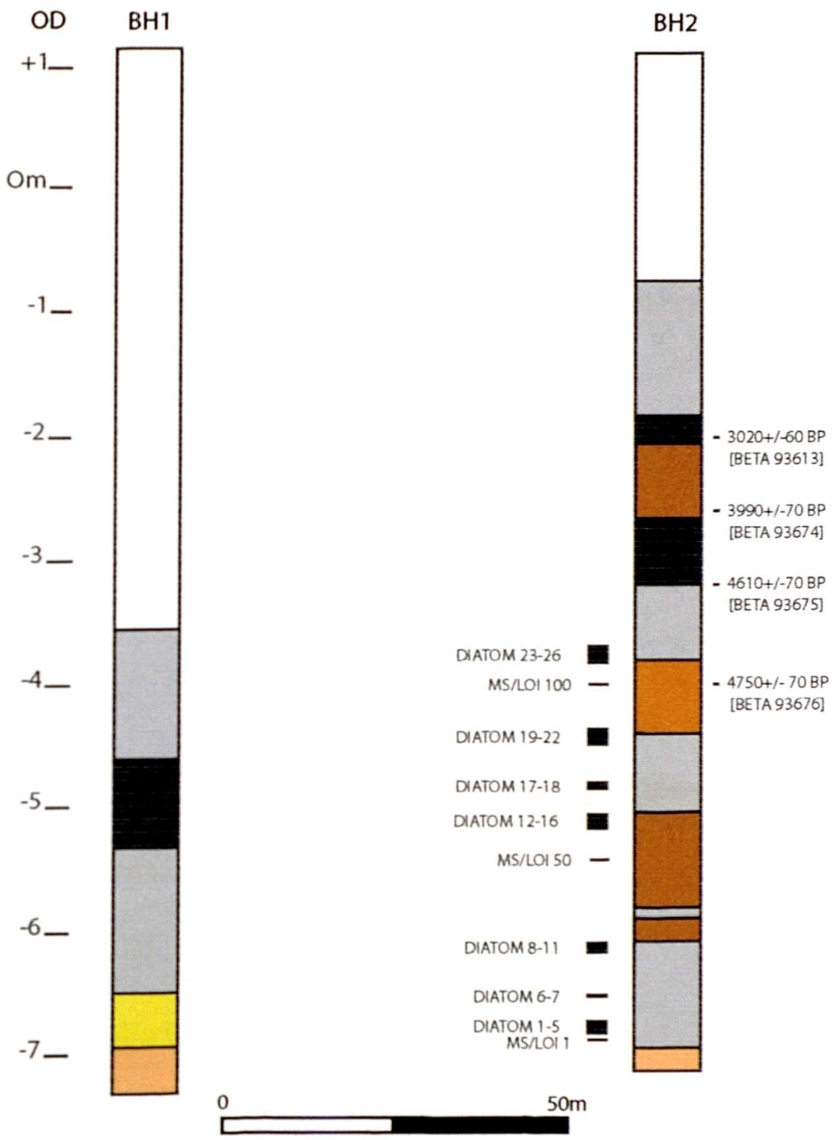



Figure 50. Voyagers Quay site outline and borehole location plan

VOYAGERS QUAY (TQ 4730 8130) LITHOLOGICAL DIAGRAM (1-2)




See Figure 91 for key

Figure 51. Voyagers Quay lithological diagram

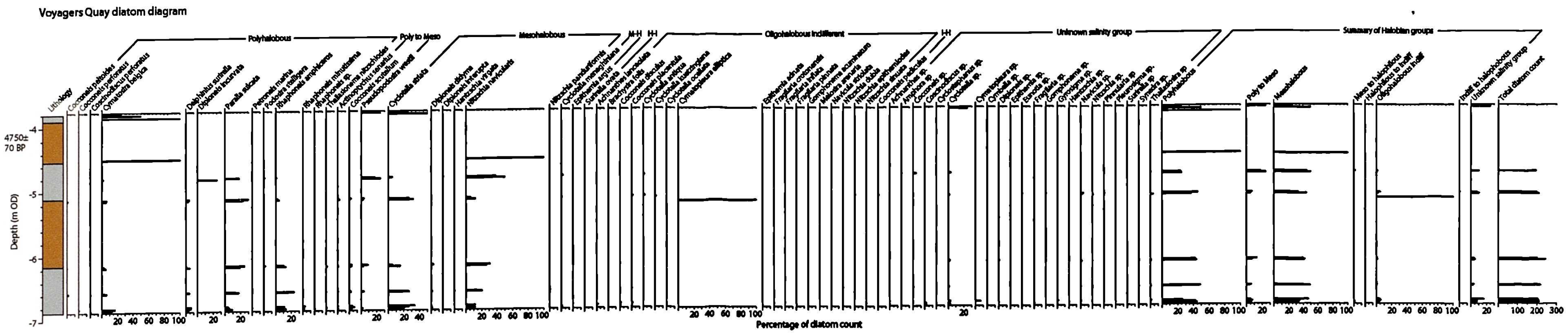


Figure 52. Voyagers Quay diatom diagram

## 5.2 The sequence

This section contains an interpretative narrative based on the collected data, which may be found in Appendix 2. The cores were all described and then BH2 was selected for detailed lithological and diatom analyses. The notes and diagram from the initial pollen scan by Dr. Rob Scaife have been incorporated, with his permission. The general sequence is of gravel overlain by finer mineral sediment, estuarine organic mud and then several peat deposits interleaved and overlain by silt clays.

### BH1

The Shepperton Terrace was encountered at -6.9m OD and consists of sand and flint gravel (see Figure 51 and also Appendix 2, Table 41). It fines up with an increasing silt component to -6.5m OD. Above the gravel is black silt clay. Such deposits have been interpreted elsewhere (Wilkinson et al. 2000) as representing migration of the braided Late Devensian/Early Holocene Thames away from the sampling location, with the fine-grained sediments representing flood deposits rather than in-channel deposition. It is possible that the site was initially located within one of the Thames channels and this was gradually abandoned. Some coarser clasts were present further up in this deposit and suggest possible erosion and re-deposition of the Shepperton Terrace with re-migration of the Thames southwards, closer to the site. Some wood and degraded organic material was also contained within the clay silt matrix.

From -6.14m OD, the deposit persists as fine silt clay but becoming laminated with some fluctuation in grain size between the individual laminae. Much undifferentiated organic matter was present and this may indicate a semi-terrestrial environment forming *in situ,* possibly within a relict channel. The laminated clay silt is overlain at -5.6m OD by a slightly coarser and structureless organic mud containing wood fragments and highly comminuted organic traces. This organic mud is laminated again between -5.5m OD and -4.6m OD where it is overlain by structureless inorganic silt clay which appears to have been subject to sub-aerial weathering at the top of the sequence where it was sealed by modern overburden.

The results of the pollen assessment from this core (see Figure 53 and Appendix 2, 2.3) indicate that the initial organic formation reflects local wooded conditions with *Quercus, Corylus avellana type, Betula, Pinus, Ulmus and Tilia* indicating typical mixed deciduous woodland. A slight change occurs at *c.* -4.1m OD where *Alnus* begins to expand to the detriment of some of the tree species such as *Fraxinus* and *Ulmus,* as a result of presumed rising base levels. This trend continues up the profile with species such as Chenopodiaceae occurring increasingly, possibly indicating local salt marsh formation, or at least inwash of estuarine waters over the sampling site. In addition, towards the top of the sequence in the silts overlying the peat, there is evidence for cereal and *Plantago lanceolata,* which may be evidence of arable cultivation taking place locally. This may have caused local run off to accumulate in the floodplain, facilitating transport of pollen grains.

Voyagers Quay

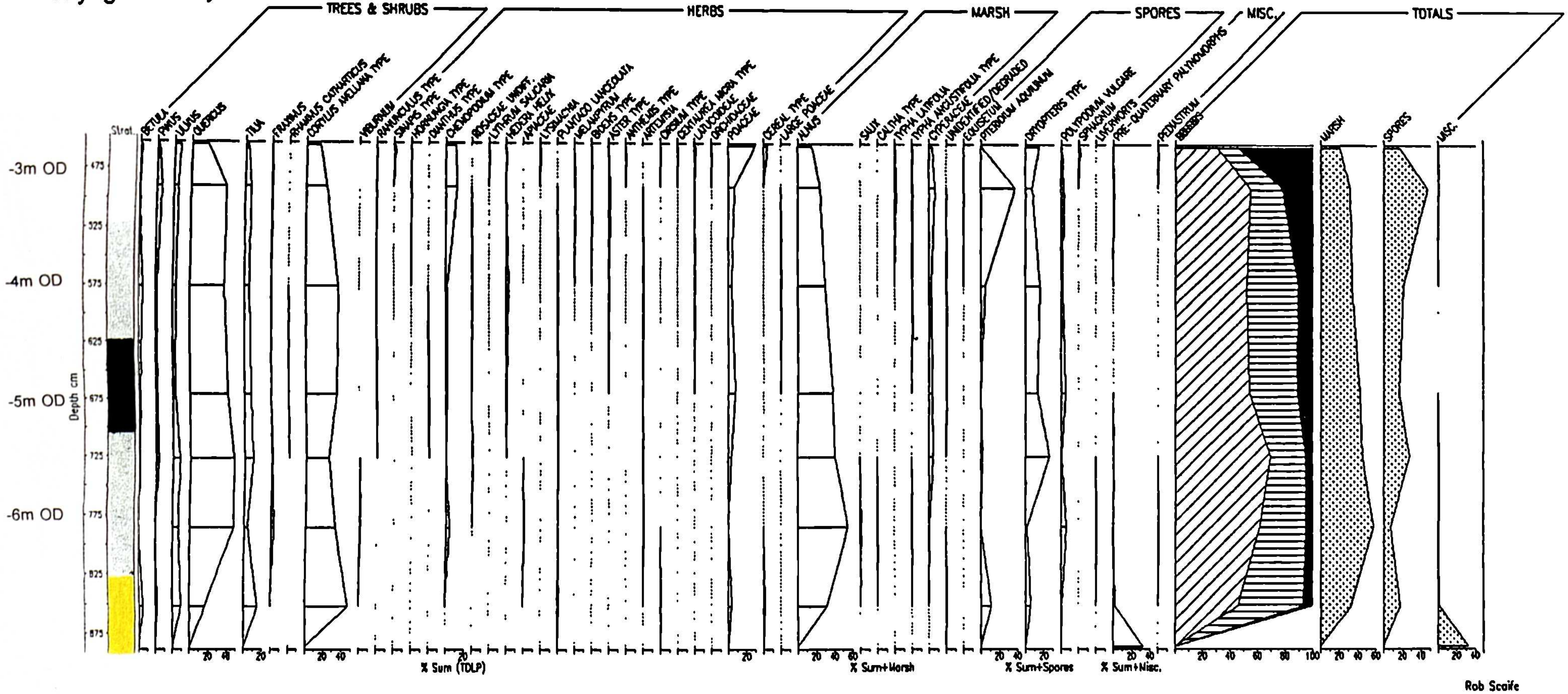



Figure 53 Voyagers Quay pollen diagram (by Dr. Rob Scaife)

## BH2

The Shepperton Terrace was recorded at -6.88m OD and consists of sand, gravel and degraded organic matter, which stained the deposit black with a percentage organic carbon content of approximately 35% (see Appendix 2, Figure 144). Magnetic susceptibility values were relatively high on the gravel surface, which could possibly indicate a period of palaeosol formation (see Appendix 2, Figure 143). The terrace is overlain by a series of silt clays incorporating woody fragments and, towards -6.1m OD, some undifferentiated organic material, but a decrease in overall organic carbon content. Preservation of organic material was variable, with occasional unidentifiable crushed leaves, suggesting a low energy aquatic environment. No diatom valves were found at the very base of the clay silt, but valves are present in samples 3, 4 and 5 (see Figure 52) with the assemblages dominated by the estuarine species *Paralia sulcata, Cymatosira belgica, Rhaphoneis amphiceros, Delphineis surirella, Cyclotella striata* and *Nitzschia navicularis* (see Appendix 2, Table 47). These species indicate that the sediment is derived from the tidal Thames. *C. striata* increases in dominance between these three samples, whilst *P. sulcata* decreases, perhaps indicating decreasing salinity or the migration of the channel away from the sampling site. However, *C. belgica* increases alongside *C. striata* whilst *R. amphiceros* and *D. surirella* remain fairly stable. It is perhaps safest to conclude by suggesting that there is a weak trend from marine to marine/brackish conditions within the context of a tidal channel depositing sediment in the intertidal zone.

Diatom samples 6 and 7, from the middle of the clay silt horizon (-6.54 and -6.52m OD) are dominated by the same species as before, indicating that poly-mesohalobian conditions remain prevalent. *C. striata* and *C. belgica* decrease whilst *Paralia sulcata* and *N. navicularis* increase slightly. Further samples (8-11) from the top of the clay silt (-6.14 to -6.08m OD) demonstrate variable preservation, with the samples at the upper contact not preserving any valves at all, possibly as a result of the sediment drying out. The samples at -6.14 and -6.12m OD did preserve diatoms and indicate that deposition continues to take place on mud flats *via* a tidal channel.

The silt clays persist to -6.06m OD where they are sealed by a thin band of humified black peat (to -5.93m OD), consisting of unidentifiable organics with some wood, detrital plant matter and moss. The change in sediment composition suggests that the area dried out considerably, possibly cut off from the Thames; which may reflect a negative tendency of sea level movement. There is a concurrent decrease in magnetic susceptibility values and an increase in carbon content to almost 60%. This value is comparable to modern values in the high marsh found by Zong and Horton (1999) at Thornham and Cowpen Marshes. The peat is overlain by 40mm of mineral sediment, sealed by a second peat deposit, again black and highly degraded, but with some reasonably well preserved wood fragments. Some clay silt was noted within the matrix, indicating that the site was still subject to inwash. The upper contact at -5.05m OD is sharp and therefore potentially erosional.

Diatom samples (12-16) were taken from the upper levels of the second peat; valves were absent below, but present above -5.11m OD. The assemblages are again dominated by *C. striata* and *P. sulcata*, with lesser quantities of *N. navicularis, C. belgica, R. amphiceros* and *Pseudopodosira westii*. The counts indicate that local conditions had changed from the assemblages present lower down; suggesting that the sampling site was in contact with the estuary and the valves were possibly being washed into the peat with mineral sediment from the river indicating the peat was forming under a positive tendency of sea level movement.

The second peat was sealed by a mineral sediment with some traces of organic matter above -5.05m OD, which, in conjunction with the diatom evidence for marine contact, supports the suggestion of a positive tendency at this point. Diatom samples 17 and 18 were examined at -4.78 and -4.76m OD. It was not possible to obtain a full count from sample 17; however, species observed included *N. navicularis, P. westii* and *Diploneis incurvata*. Valves were much better preserved in sample 18, which was dominated by *N. navicularis, P. sulcata* and *P. westii*. In comparison with previous samples, *C. striata* values plummeted whilst *P. westii* and *N. navicularis* increased sharply. This shows a continued strong marine signal and a slight change with the increase of *N. navicularis* indicating an expansion of intertidal mudflats (Vos and de Wolf 1993).

A third peat seals the mineral sediment from -4.43m OD. Diatom samples (19-22) across the contact are almost entirely devoid of valves with only a few marine species present. The peat once more consists of highly humified black, mainly unidentifiable, plant matter. Wood was noted along with some stem tissue. A radiocarbon date (see Appendix 2, Table 45) of 4750±70 BP (Beta 93676; 3660-3370 cal BC, -3.95 to -3.90m OD) was obtained from wood present in the upper levels of this peat, which is overlain by laminated silt clay with sand above -3.79m OD. Some organic matter (reaching 50% TOC) is present and may indicate periods of exposure within the cycle of lamination. Diatom samples from the silt clay were poor in valves with only a few species present, such as *Cyclotella striata*, *Cymatosira belgica,* and *Pseudopodosira westii.* Although so few valves cannot be reliably interpreted, it is possible that the presence of *Cyclotella striata* indicates a slight freshening from the previous levels.

Unfortunately, above -3.59m OD, the cores were mislaid after the initial scan. Nevertheless, in the absence of full Troels-Smith logs, the initial descriptions are incorporated here along with the radiocarbon dates obtained from this part of the stratigraphy. The upper level of the laminated silt clay dates to 4610±70 BP (Beta 93675; 3630-3090 cal BC, 3.31 to -3.27m OD), and is sealed at *c.* -3.25m OD by an organic mud that persists until *c.* -2.65m OD where is it overlain by a fourth peat. This contact dates to 3990±70 BP, (Beta 93674; 2850-2300 cal BC, -2.60 to -2.55m OD). The peat persists to *c.* -2.05m OD, where a further organic mud seals it, the base of which dates to 3020±60 BP (Beta 93673; 1430-1020 cal BC, -1.97 to -1.95m OD). The organic mud was sealed by minerogenic silt clays at *c.* -1.7m OD, that persist to *c.* -0.75m OD where the modern overburden begins.

## 5.3 Site summary

The sequence is locally variable in that BH1 records only limited organic formation whilst BH2 contains multiple peat beds. Erosion in BH1 may have removed some terrestrial sediment and indeed local terrestrial conditions are indicated in the pollen sequence that initially shows local woodland conditions demonstrating a mixed deciduous ecology, with rare survival of *Pinus.* Nevertheless, the sediments from this core range from the high energy deposits at the base of the sequence to the laminated fine-grained sediments which almost certainly indicate the presence and infilling of a channel. Again, the pollen evidence indicates alder carr subsequent to the woodland species, which confirms the continued presence of vegetation communities, but also supports the idea of a waterlogged environment. This is strengthened with the subsequent rise of species such as *Chenopodium*, indicating a transfer again at the sampling site to a salt marsh environment. Interestingly, there is evidence for human occupation in the form of ruderals species and cereal pollen. It seems possible that cultivation of the landscape, if it is indeed representative of local conditions and not water-borne pollen, may well have contributed to the waterlogging of the floodplain by increasing runoff from the higher ground to the south.

BH1 contrasts strongly with BH2 (see Figure 54) where four distinct peat horizons are present with several organic mud horizons as well, rather than a mainly minerogenic sequence. The closeness of the boreholes suggests that this difference is a result of a localized topographic feature, such as a channel. It seems likely that BH2 is more typical of the broader local conditions, and on the basis of the frequent changes in sediment type, this would seem to indicate a dynamic environment. This could be the result of, for instance flooding from a nearby channel or the sampling site being located at the boundary between marsh and tidal flats and consequently subject to frequent fluctuations in depositional environment ranging from wood peats to intertidal muds. In this respect, the site may be considered a sensitive indicator for Thames-side conditions, but perhaps may be too sensitive to local conditions to be a good indicator for larger stretches of the estuary.

The diatom sequence is generally consistent throughout BH2. Almost all samples where full counts were obtained are dominated by the species *Paralia sulcata, Cymatosira belgica, Rhaphoneis amphiceros, Delphineis surirella, Cyclotella striata, Pseudopodosira westii* and *Nitzschia navicularis*. There are changes in the proportions of species within each assemblage, but the general pattern indicates minor fluctuations within the bankside ecology of a tidal channel. Unfortunately, diatom preservation was not consistent, with several samples where counts could not be obtained. Therefore, it is not possible to identify whether the aquatic conditions changed significantly in the early periods of organic deposition. The presence of assemblages suggesting tidal conditions from the sediment overlying the gravel terrace is interesting, suggesting early tidal influence in this location. The sequence appears to confirm much of what Spurrell recorded in 1889 with several peat horizons and evidence for estuarine waters low in the sequence. It is interesting to note that although Spurrell recorded *Taxus* there was no sign of it in the pollen record here, showing the problems of pollen taphonomy, as seen at Wennington Marsh.

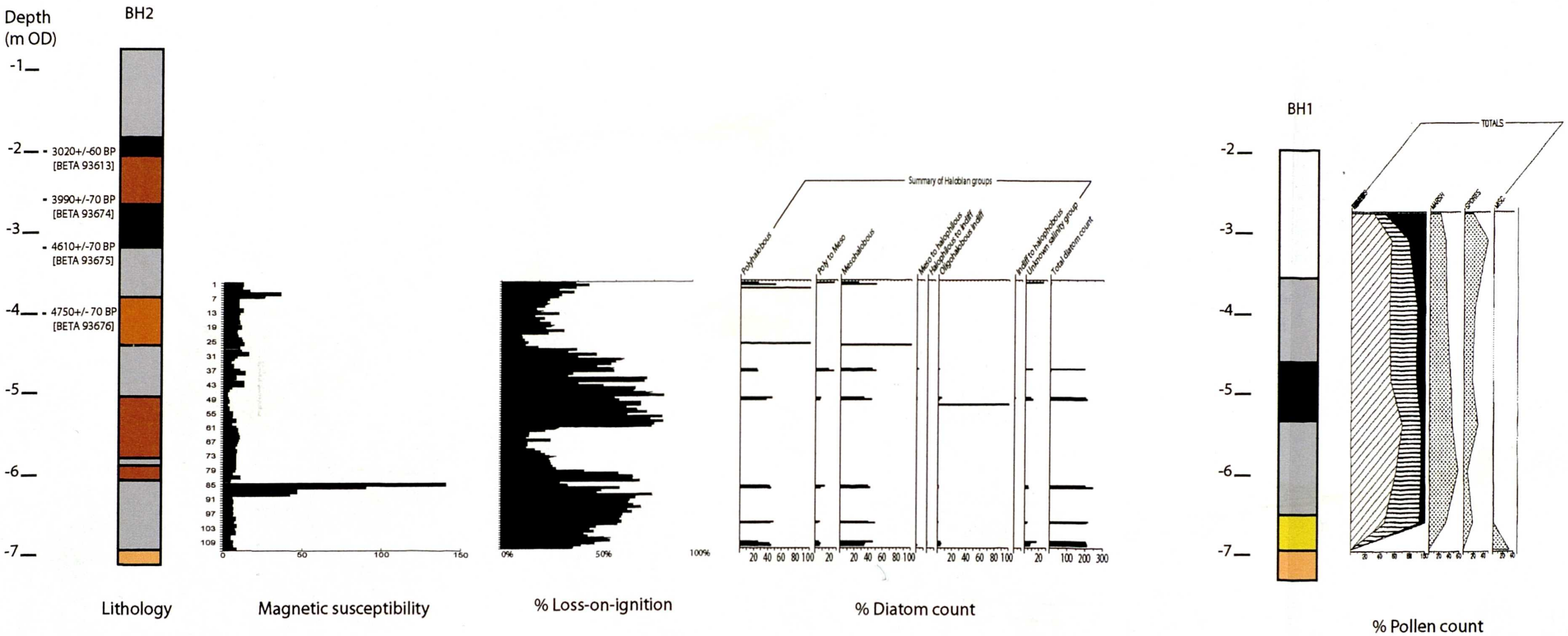



Figure 54. Voyagers Quay summary diagram

# *Chapter 6. Gallions Reach Urban Village, Thamesmead, London Borough of Greenwich, SE28 (TQ 4490 7985)*

## 6.1 Introduction

### Site Location

Gallions Reach urban village (code GAH96, GLSMR 071491, 1 on Figure 55) lies within part of the modern development of Thamesmead on the south bank of the Thames in Greenwich. It is adjacent to the stretch of the Thames known as Gallions Reach, bounded to the south by the Western Way, to the north by Warepoint drive and the Thames itself. On the western side is Gallions Park and lake (2 on Figure 55) whilst on the east lies the site of the London river crossing. The land is just to the southwest of the prominent angle jutting into the Thames; Margaret or Tripcock Ness (3 on Figure 55). It is east of the Woolwich Arsenal (4 on Figure 55) and was examined prior to redevelopment of land associated with the Arsenal. The Arsenal previously employed the land for testing mortars and armour piercing weapons until it was abandoned in the 1970's and 1980's. It has since been used as a tip with a small quarry. Prior to its use by the Arsenal, the land was been known as the Plumstead Marshes, and is presumed to have been an open area of marsh throughout most of the historic and probably the later prehistoric periods.

### Previous work

Very little examination of the stratigraphy of this area has been undertaken, mainly because it was part of the Woolwich Arsenal for several hundred years. A discussion of the stratigraphy recorded nearby by Devoy (1979) and Spurrell (1885, 1889) at Plumstead, Crossness, compared with Beckton and Dagenham (5-8 on Figure 55) may be found in the introduction to Chapter 5; gravel was found at between -2.5 and -7.5m OD, overlain by sand sealed by a possible palaeosol. This was overlain by a relatively thin peat, clay and then a second peat sealed by a thick estuarine clay facies.

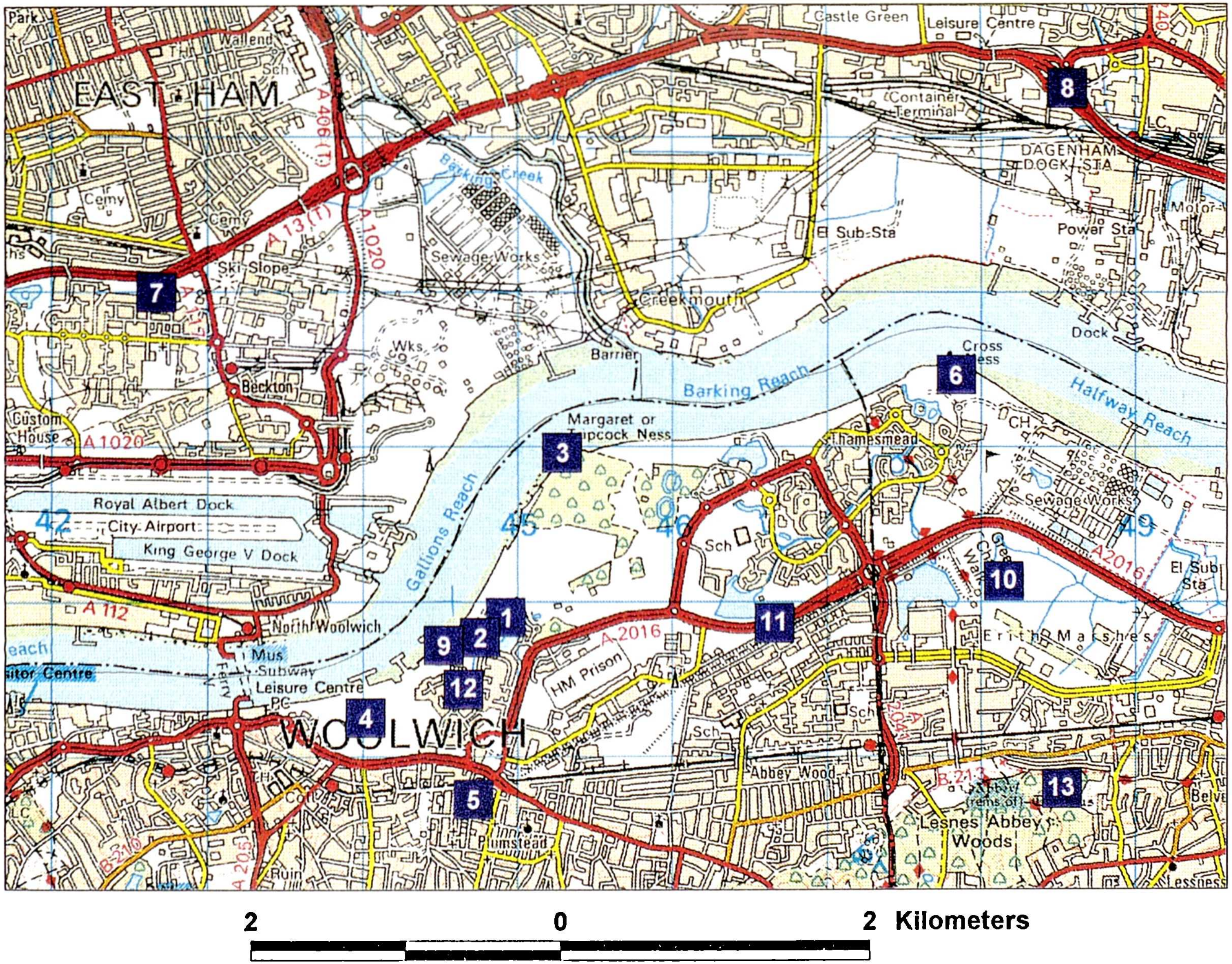



Figure 55. Location map of Gallions Reach and other sites mentioned in this chapter

| No. | Sites | Eastings | Northings |
|---|---|---|---|
| 1 | Gallions Reach | 4490 | 7985 |
| 2 | Gallions Park and Lake | 4480 | 7975 |
| 3 | Margaret/Tripcock Ness | 4525 | 8098 |
| 4 | Woolwich Arsenal | 4400 | 7925 |
| 5 | Plumstead | 4470 | 7870 |
| 6 | Crossness | 4780 | 8150 |
| 7 | Beckton | 4270 | 8200 |
| 8 | Dagenham | 4860 | 8330 |
| 9 | Thamesmead 8B | 4450 | 7965 |
| 10 | Devoy's Crossness site | 4815 | 8015 |
| 11 | Church Manor Way | 4662 | 7988 |
| 12 | Woolwich East | 4462 | 7942 |
| 13 | Belvedere | 4850 | 7875 |

Table 19. Sites shown on Figure 55

An examination of Thamesmead site 8B by the Geoarchaeological Service Facility (GSF) (Pine 1994, 9 on Figure 55) recorded peats and silt clays (GLSMR 071169, 70, 71). The interpretation of the sequence was that it consisted of buried land surfaces dating to the Mesolithic/Early Neolithic periods, marginal to a major channel, with the subsequent peat beds dissected by tributaries. The area is thought to have been subject to erosion and reworking on the basis of the complex stratigraphy recorded here.

Devoy also recorded sequences (1979, figure 28) at Church Manor Way (11 on Figure 55) slightly to the southeast of Gallions Reach and at Woolwich East (12 on Figure 55), very close to the Gallions Reach site. No dates are available for these sites. The sequence at Church Manor Way has gravel at *c.* -9.5m OD overlain by a substantial (3m thick) Tilbury II deposit, sealed by several more metres of clay silt, and then Tilbury III peat between approximately -5.0 and -1.5m OD. No further organic material was present here. Woolwich East has gravel at *c.* -4.75m with no Tilbury II, a relatively thin clay-silt between -5.0m and -4.0 OD. The Tilbury III deposit is present between *c.* - 4.0 and -1.5m OD, sealed by further mineral sediment. This sequence is reasonably consistent with the deposits at Crossness (10 on Figure 55), but not very comparable with Church Manor Way (also see Figure 56).

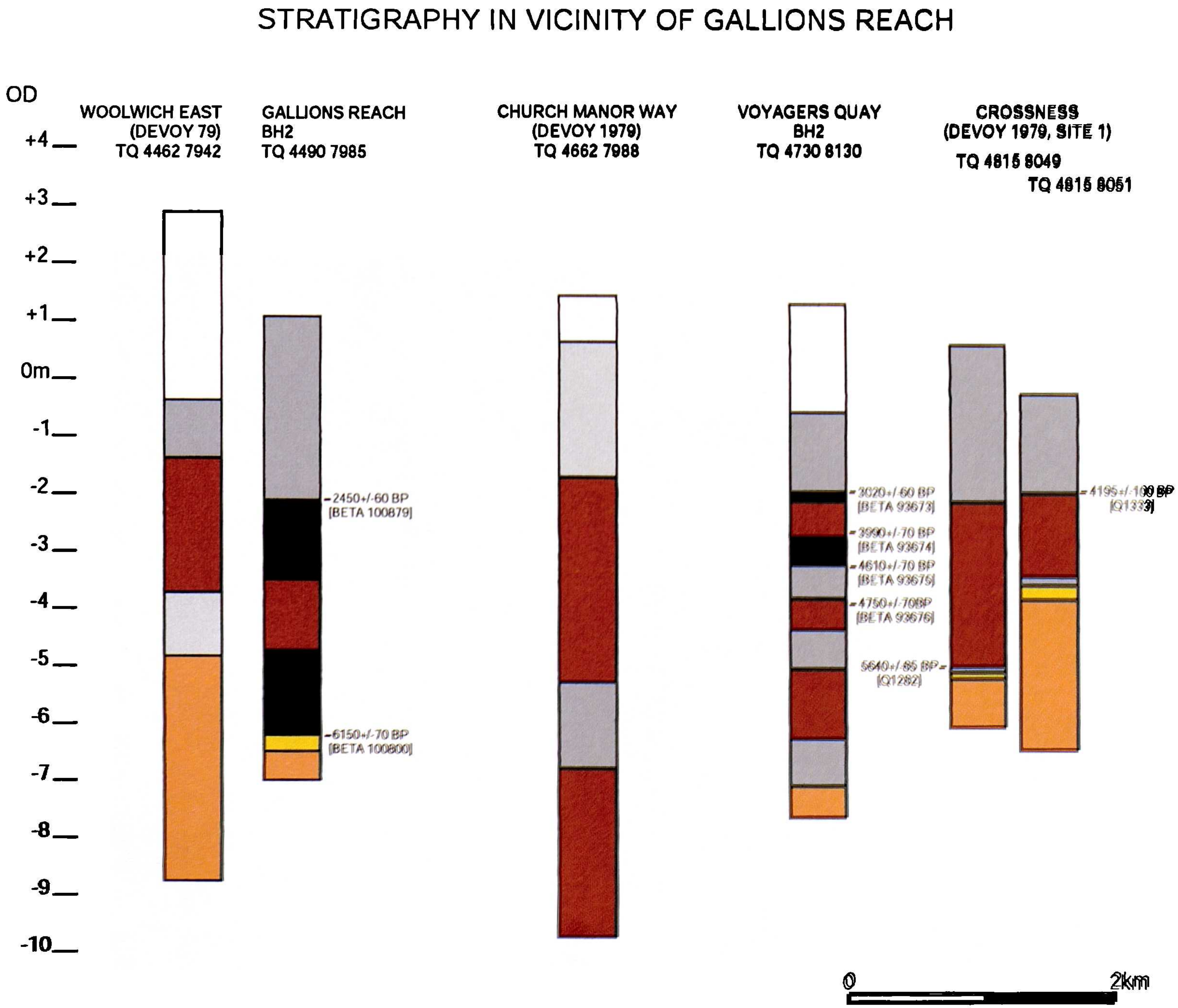



Figure 56. Stratigraphy in the vicinity of Gallions Reach. See Figure 91 for key

Although the area has not been intensively archaeologically investigated, some interesting material has come to light, mostly by chance. River finds include prehistoric (GLSMR 070566) and Roman pottery on the foreshore (GLSMR 070328, 070327). More spectacular finds include a Neolithic dugout canoe from Belvedere (GLSMR 070415) (13 on Figure 55), several Bronze Age bronze swords from the river (GLSMR 060197, 060196), with another Bronze Age weapon dug from the marshes in 1778 (GLSMR 070216). Preserved wood was also noted at a depth of two metres during the construction of the drain that this weapon came from (Mills Whipp Partnership 1995). Other finds on the marshes include Mesolithic and Neolithic struck and fire cracked flint (GLSMR 071501), a Mesolithic awl (GLSMR 070514), undated human remains (GLSMR 071065), and a series of World War II defences (GLSMR 071458).

The medieval use of the area is very poorly understood and may simply have involved grazing. One documentary source suggests that the area was frequently flooded and required defensive work from the 10$^{th}$ century. Henry II ordered Emeline de Ros to pay the Abbot of St Augustine's abbey for works and defences of her part of Plumstead. These are thought to be river defences built during the reign of Henry I by her ancestors in Sandhopeness (Margaret Ness), indicating that the river wall was built from at least the early 12$^{th}$ century (Mills Whipp Partnership 1995). Spurrell's (1885) examination and map of the river walls indicates that the land at Gallions Reach may have been subject to regular flooding with a wall set significantly back from the river and another (later?) wall close to the Thames defending the land here. This could have occurred when the land was required for the Arsenal; the absence of fields marked on the map used by Spurrell indicates that the land was not used previously, unless for grazing.

## The Project

An archaeological project was undertaken in advance of housing development. Eight boreholes were drilled using a cable percussion shell and auger rig to characterize the deposits across the area and identify possible palaeosols that could have supported human occupation (see Figure 57). U4/100 samples were collected from the undisturbed sequences within all boreholes. The sampling strategy involved detailed description and dating of all cores, which are presented here followed by a cross-site synthesis.

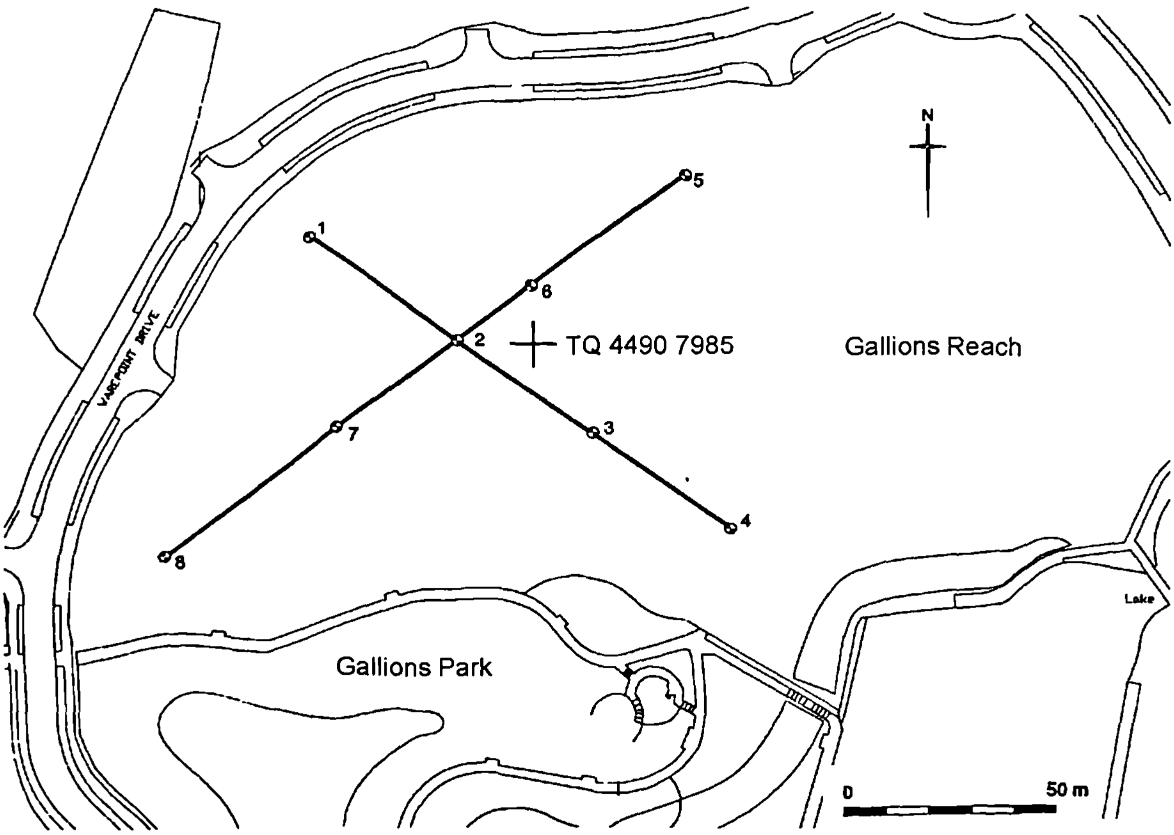



Figure 57. Gallions Reach site outline and borehole location plan

A preliminary assessment, *sensu* MAP2 (English Heritage 1991) was carried out which listed the sequences, obtained preliminary dates and briefly examined the biostratigraphy. On the basis of the assessment, the site was selected for inclusion in this project and the criteria for inclusion were:

- *The central position relative to other sites in the project*
- *Location within the Devoy model area*
- *The large number of cores*
- *The opportunity to examine Holocene sea-level tendencies*
- *Good chronological data*
- *Reasonable biological preservation*

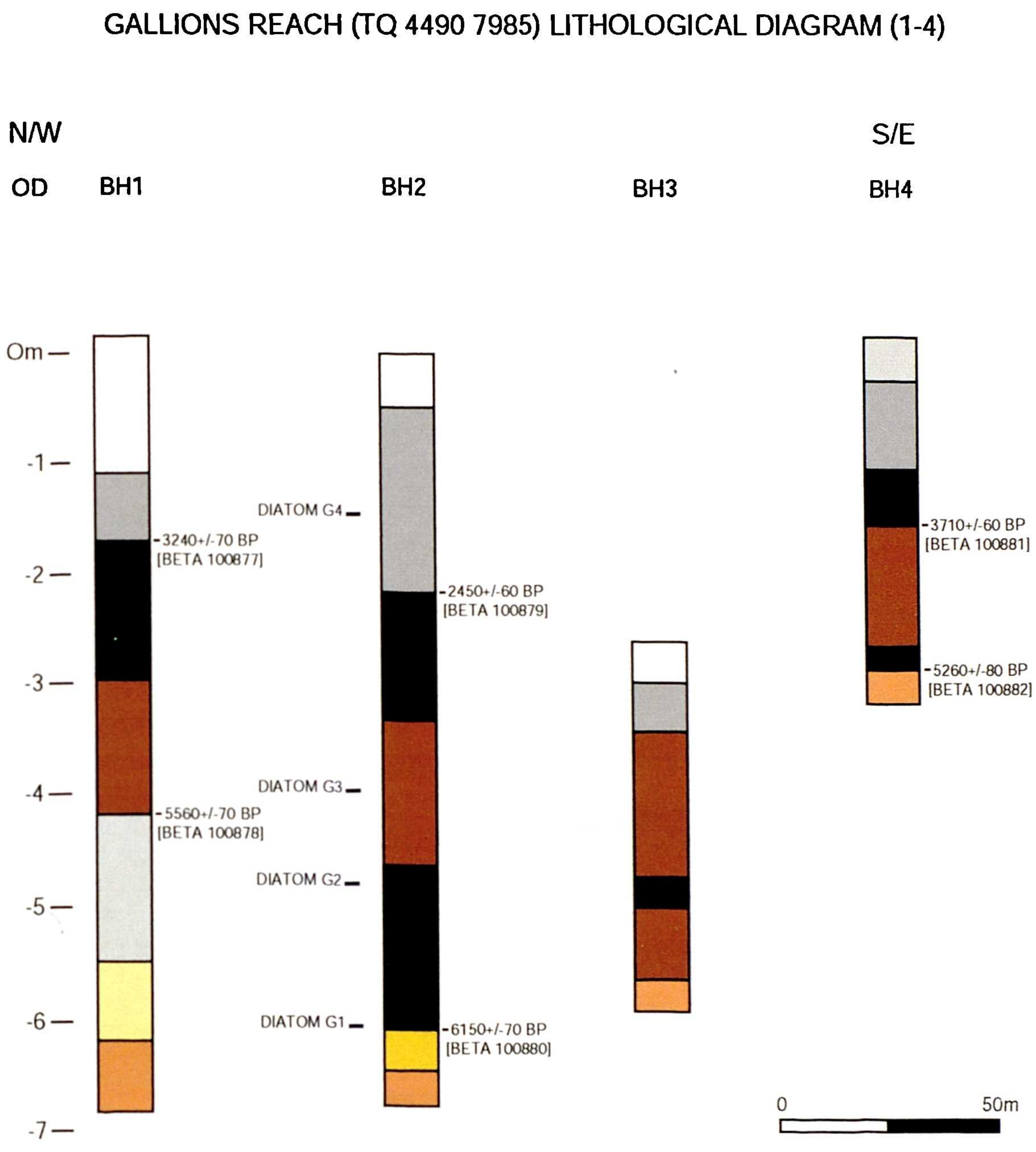



Figure 58. Gallions Reach litological diagrams, BH1-4. See Figure 84 for key.

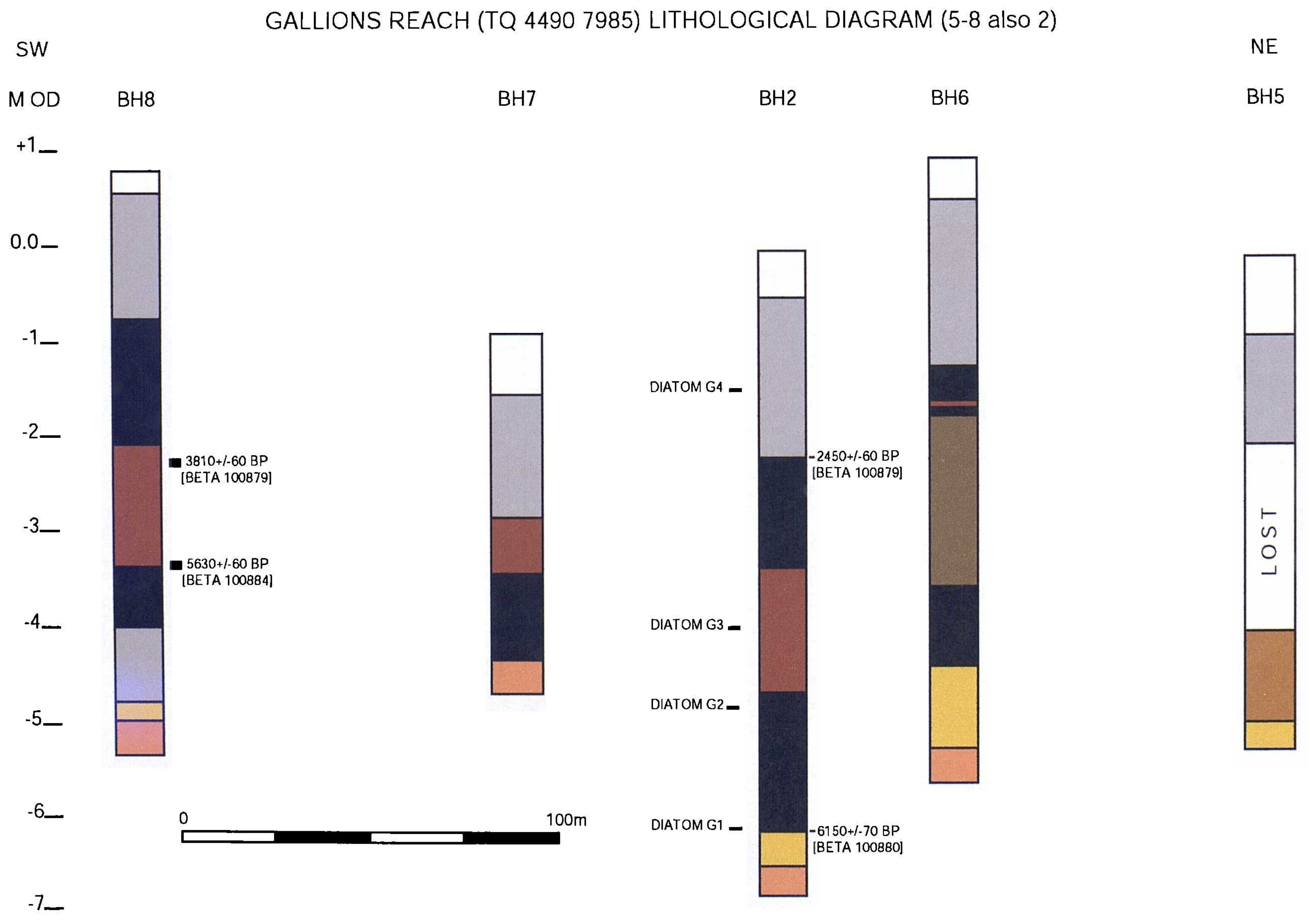



Figure 59. Gallions Reach lithological diagram, BH5-8 (also 2). See Figure 91 for key

## 6.2 The Sequence

This section describes and interprets the stratigraphic sequence; full data may be found in Appendix 3. The cores were described and subsequently BH2 was selected for analysis. The general sequence is of Pleistocene gravel overlain by organic mud sealed by a substantial peat horizon. This in turn is sealed by further organic muds and finally estuarine clay silts (see Figures 58 and 59).

### BH1

The Shepperton Terrace occurs below -6.2m OD, and is sealed by silty sand, which gradually fines upwards and includes some organic matter, i.e. at *c.* -5.8m OD (see Appendix 3, Lithology). From -5.5m OD the silty sand is replaced by a clay silt sand, with some wood at *c.* -4.6m OD. This continues to fine upwards with a higher organic content, including wood and highly degraded plant matter. The upper contact (possibly eroded) of the silty sand (-4.22m OD) is overlain by a humified black woody peat. This contact is dated to 5560±70 BP (Beta 100878; 4540-4250 cal BC, -4.25 to -4.20m OD, see Appendix 3, Table 58). There is a low mineral content present within the peat, suggesting that inwash over the site continued to occur. The peat, although humified throughout, changes in composition towards the top, where more herbaceous plant remains are present, indicating a change in ecology from wood to sedge peat. Above *c.* -3.0m OD the mineral content increases significantly and the sediment changes to an organic mud, comprising clay silt and undifferentiated organic matter. Some sand and wood fragments are present, but the clay content increases upwards to -1.68m OD. This level is dated to 3240±70 BP (Beta 100877; 1690-1320 cal BC, -1.73 to -1.68m OD) and was overlain by clay silt with no organic inclusions at all. Iron staining was noted and may be evidence of the site having been exposed for some time. The dating outlined for this borehole indicates that organic deposition occurred for just under three thousand calendar years with *c.* 2.5m of accumulation, roughly 10mm per 12 years, uncorrected for compaction.

### BH2

The Shepperton Terrace occurs below -6.47m OD and fines upwards with organic inclusions above -6.32m OD. The sand of the terrace is sealed at -6.17m OD by a band of highly humified peaty mud with traces of wood and other plant parts; dated to 6150±70 BP (Beta 100880; 5300-4850 cal BC - 6.17 to - 6.12m OD), i.e. Late Mesolithic. Diatom samples from this peat contained only a few valves (see Appendix 3, Table 60); the poor preservation probably a result of the conditions which led to the humification of the organics. The few valves present indicate that the deposit was predominantly freshwater, although *Cocconeis placentula* will tolerate brackish conditions. The mineral content increases and the overlying deposit is an organic mud (recorded above -5.81m OD) comprising mineral sediment with some completely degraded organic material and some wood. Diatom valves from the top of the organic mud were lacking, with the exception of sample 10 (-4.71m OD). This assemblage was dominated by poly-mesohalobian species including *Paralia sulcata, Cyclotella striata, Pseudopodosira westii* and *Rhaphoneis amphiceros,* indicating deposition from tidal inlets and estuarine channels (Vos and de Wolf 1993). *Nitzschia navicularis* is also present and dominates the assemblage. This taxon, although also a marine/brackish indicator, is also found on intertidal mudflats and this is likely to be the main ecotype represented at this point in the sequence (see Figure 60). Pollen from the peat and organic mud indicates mixed deciduous woodland nearby including *Quercus, Corylus avellana* type, *Tilia, Fraxinus, Ulmus* and *Hedera helix* (ivy) (see Figure 61). The organic mud appears to have formed in and around an environment of mudflats and tidal creeks whilst the peat was forming under an alder carr.

The organic mud is overlain from -4.65m OD by a humified peat, a much thicker deposit which persists to -3.39m OD. This peat contains very little identifiable organic material other than wood; nevertheless the total percentage organic carbon was high throughout, reaching values of 92% but averaging approximately 85% through the entire sequence (see Appendix 3, Figure 147). The $\chi^{r}$ values obtained through the peat show isolated lenses which appear to have slightly more mineral sediment, i.e. where the values exceed zero, with an obvious trend towards the top of the peat, reaching over 10 $m^3 kg^{-1}$ (see Appendix 3, Figure 146). Several samples were examined for diatoms in the peat but very few valves were recovered; those that were indicate that the site was still in contact with the estuary on the (admittedly scanty) evidence of a few valves of *Pseudopodosira westii, Paralia sulcata* and *Nitzschia navicularis.*

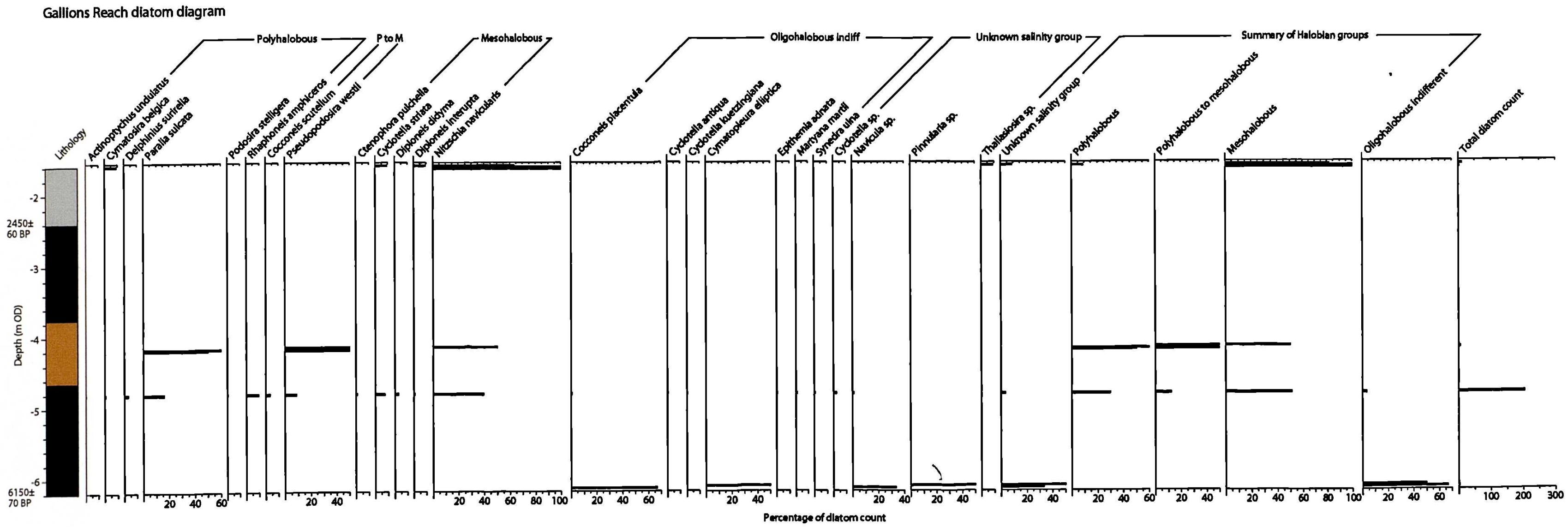



Figure 60. Gallions Reach diatom diagram

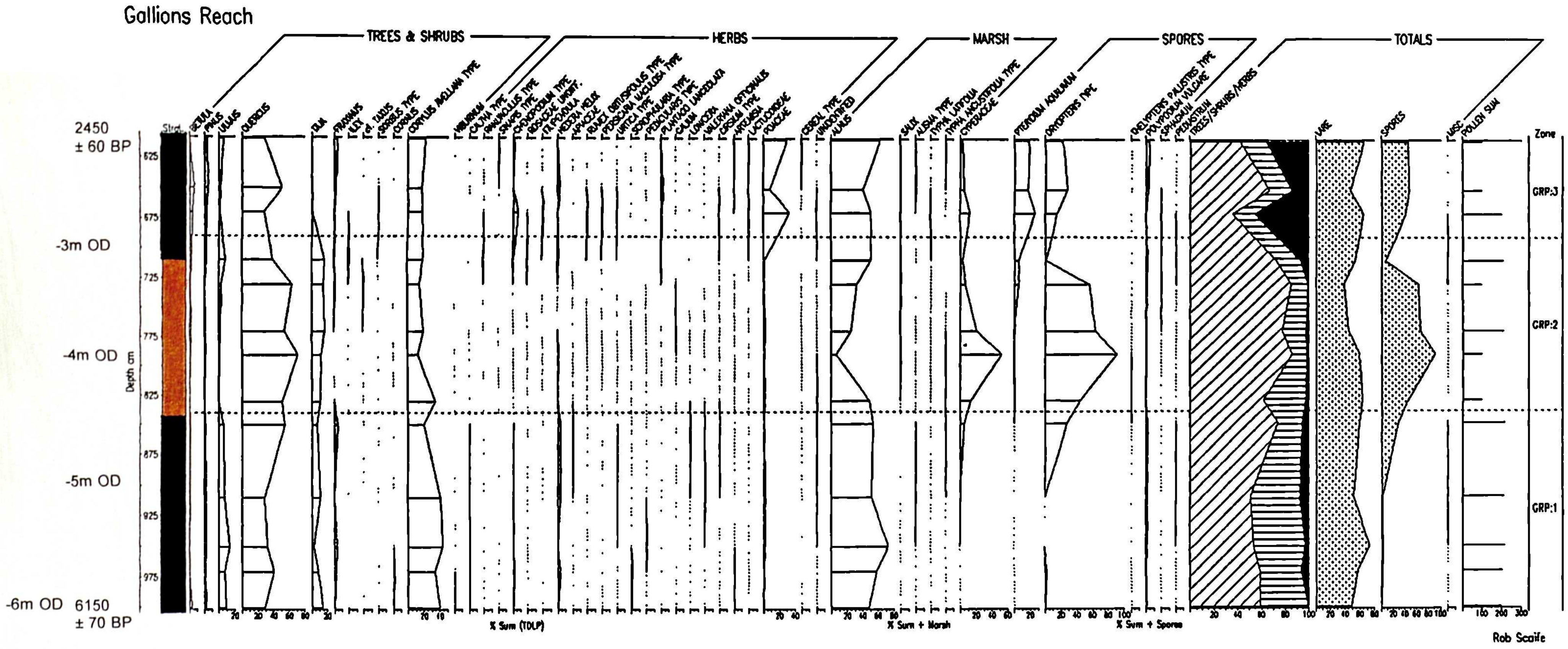



Figure 61. Gallions Reach pollen diagram, by Dr. Rob Scaife

Pollen samples in this peat indicate an alder carr environment, similar to the lower humified peaty mud; however, the dominance of alder decreases against Cyperaceae within this peat horizon. The woodland element, presumably on the higher land to the south, continues to be dominated by *Quercus,* but *Ulmus* and *Fraxinus* decrease in numbers through the sequence. The decline in *Ulmus* could represent the well-documented elm decline seen across London in the Neolithic (Greig 1992). *Tilia* is still present in the spectra at this point, which might indicate that only localized clearance occurred, thought to have subsequently led to widespread elm eradication through the action of *Scolytus scolytus* (elm bark beetle).

There is a low mineral content within the peat, which increases at the top of the deposit where it is sealed by a black organic mud at -3.39m OD. The percentage of organic carbon at this transitional point drops rapidly to 60%. Iron staining occurs at the base of the organic mud, perhaps indicating that it was subject to sub-aerial weathering. The organic carbon content fluctuates between 8 and 84%. The $\chi^{lf}$ values remain low, but higher than those found in the peats below. However, at the top of the deposit, a value of 94 $m^3 kg^{-1}$ was recorded, and is sufficiently high to indicate an unusual occurrence at this level. This could indicate that the site stabilized briefly and pedogenesis began, or it may simply reflect local burning, although no charcoal was noted in the core. Pollen within the organic mud shows that *Alnus* regains dominance, but with the appearance of *Chenopodium* type which may indicate a development of local salt marsh. The woodland element persists, with *Quercus* and *Corylus avellana* type still present, although *Tilia* is not. Poaceae and *Plantago lanceolata* (ribwort plantain) may indicate arable cultivation nearby. The organic mud was over a metre thick, only sealed at -2.2m OD, with some evidence for a small period of wetland expansion at -2.4m OD where a thin band of humified peat occurs.

The top of the organic mud is slightly eroded, but was dated to get a minimum date for the end of organic sedimentation. The result was 2540±60 BP (Beta 100879; 830-410 cal BC, -2.25 to -2.20m OD). This falls within the plateau of the radiocarbon curve for the first millennium cal BC and spanning the Late Bronze to Early Iron Age. The organic mud is sealed by a fine-grained mineral sediment which coarsens upwards with sand at the top. Organic carbon content fluctuates but averages approximately 10%

throughout, which is unlikely to represent *in situ* growth, and fits well with figures obtained by Zong and Horton for the perimarine/low marsh zone (Zong and Horton 1999). Magnetic susceptibility values are generally low and therefore consistent with deposition of mineral sediment; however, a value of nearly 300 $m^3$ $kg^{-1}$ was obtained from -1.76m OD, which may indicate burning or soil formation. It was present at the top of a U4 core and so may be modern contamination. Diatom valves are poorly preserved in this upper deposit, with the assemblage dominated by *Nitzschia navicularis,* suggesting differential preservation and/or that the local environment was one of intertidal mudflats. The modern overburden is present at -0.61m OD

### BH3

The sand and gravel of the Shepperton Terrace occurs at -5.66m OD and is overlain in this borehole by some highly degraded wood, sealed by an peat with further wood fragments. Mineral sediment is also present within the matrix and also as discrete laminae. Above *c.* -5.0m OD the mineral content increases and the sediment changes to a black organic mud, which contains some wood fragments. It is sealed at -4.76m OD by an increasingly organic horizon almost 1.5m thick. Both wood and traces of herbaceous plants are present. Some mineral sediment is present and so it seems likely that the sampling site continued to be inundated, but the with peat formation more significant than mineral inwash. The peat is sealed between -3.45 and -3.40m OD by a silt clay, indicating that rising water levels inundated the site from this point. There is a thin organic band within this silt clay, which suggests that the marsh expanded briefly once more before being finally submerged.

### BH4

The sand and gravel of the Shepperton Terrace was recorded between -3.13m and -2.88m OD, gradually fining upwards. It is sealed by organic mud, which also fines upwards until replaced by a peat bed from *c.* -2.7m OD. The base of the organic mud was dated to 5260±80 BP (Beta 100882; 4320-3940 cal BC, -2.86 to -2.81m OD), the Mesolithic/Neolithic transition. The organic mud is sealed by a highly humified wood peat with some herbaceous remains. It persists to -1.57m OD where it is sealed by further organic mud showing the increased influence of the river. This upper contact dates to 3710±60 BP (Beta 100881; 2290-1920 cal BC, -1.61to -1.56m OD) indicating the peat took roughly 2000 years to accumulate.

Some detrital plant material is present within the matrix of the organic mud over the peat and it is likely that the site was not continually submerged, but close to a channel, presumably the Thames. The organic mud is sealed at -1.16m OD by a coarser mineral sediment, indicating that the channel is by this point much closer to the sampling site and inwash occurred more regularly. From -0.66m OD the coarse mineral deposit is replaced by laminated organics and silt clays that seem to indicate a gradual cycle of organic formation, perhaps indicating the wetlands expanded but not consistently seawards, interspersed with deposition of estuarine clays. The final deposit in this location shows a coarsening of the mineral component from -0.35m OD, indicating that the site is being inundated under higher energy conditions.

## BH5

The Shepperton Terrace was encountered at -5.11m OD, overlain by a clay silt sand with some wood, which fines upwards and becomes laminated with fine sand and humified organic matter, indicating that deposition may have occurred within a periodically active channel. A break in the sequence occurs between -4.17 and -2.12m OD owing to several U4/100 samples having been mislaid. Site records indicate that the missing stratigraphy was a silt clay. From -2.12, the sequence consists of further minerogenic sediment, exhibiting thinly bedded deposits of fine-grained silt clay and coarser silty sand. Humified organic material is present within the finer sediment and again may suggest that the deposit is still forming within a palaeochannel that is only occasionally active.

## BH6

The Shepperton Terrace is present at -5.35m OD, overlain by a degraded wood peat. Some mineral sediment is present within the matrix and increases in quantity to the point (*c.* -4.5m OD) where the peat is sealed by a black organic mud. A second, more substantial humified wood peat is present between *c.* -3.6m and -1.8m OD where it is sealed by a further thin band of organic mud. This in turn is sealed by a third thin peat horizon, to *c.* -1.6m OD. A thicker deposit of laminated mineral/organic lenses is present to -1.2m OD. This pattern suggests that the sampling site was at the very edge of the wetland margin where peat could form for short periods but was inundated regularly. A deposit of purely mineral sediment, in some places fairly coarse, concludes the sequence suggesting in-channel sedimentation. There is also some iron staining which may indicate that at other times the sampling site was exposed.

**BH7**

The Shepperton Terrace occurs at -4.33m OD where it includes some degraded organic material and is sealed by organic mud containing some wood. The mineral component fines upwards indicating continued, although decreasing, influence from a large channel. The organic mud is replaced by a degraded peat between -3.44 and -2.83m OD, which contains traces of wood and herbaceous plants. Some mineral sediment is present within the peat, which suggests that although the peat reflects a major period of wetland development, it is still subject to inundation, presumably from the Thames. The peat is gradually overlain by mineral sediment, with some organic content, indicating that the translation from semi-terrestrial peat to tidal deposition occurred fairly gradually. The presence of some gravel clasts and sand towards the base of the mineral deposit suggests that the process may have begun relatively gradually but with an increasing rate of flow over the site. The upper part of the deposit fines upwards.

**BH8**

The Shepperton Terrace is present below -5.03m OD where it is overlain by a laminated sand. The deposit gradually fines up with silt clay above -4.8m OD, however, it coarsens again at approximately *c.*- 4.0m OD. Some gravel clasts are present indicating that the sampling site may have been within the main channel at this point. The upper contact to the overlying organic mud was erosive, indicating a hiatus. The organic mud is approximately 0.7m thick and is sealed by a humified peat bed above -3.35m OD, the base of which dates to 5360±60 BP (Beta 100884; 4340-4000 cal BC, -3.35 to -3.30m OD), the Late Mesolithic. The peat contains wood throughout and possible *Phragmites* (reed) remains. It persists for approximately 1.15m where it is sealed at -2.08m OD by a mainly mineral sediment with a low organic content. The upper levels of the peat (not quite the contact, but the nearest point yielding enough organic matter for a result) date to 3810±60 BP (Beta 100883; 2460-2040 cal BC, -2.25 to -2.20m OD) showing that peat accumulation continued into the Bronze Age and that the first metre, approximately, took 2000 calendar years to accumulate. The mineral sediment coarsens upwards with a decrease in the organic content to the point (+0.16m OD) when no organic matter remains and the deposit is wholly minerogenic, probably reflecting in-channel sedimentation.

## 6.3 Site summary

The results indicate variable stratigraphy across the site. Gravel is lowest in BH2 and BH1, below -6.0m OD, which may indicate a palaeochannel cutting through the gravel in this location, or simply that the gravel dips towards the Thames from higher ground to the south. The altitude of the gravel along the north-east/south-west line is relatively consistent, ranging from -4.33m OD to -5.35, with the exception of the low point in the area of BH2. Gravel is present at -2.88m OD in BH4, which indicates the likelihood of a gravel island in this location. There is no evidence for this is the area of BH3 where the gravel occurs below -5.66m OD. These two holes are less than 40m apart, so the change in altitude is likely to have represented a quite obvious topographic feature and one that may have retained some prominence in later periods.

No obvious traces of a palaeosol survive over the gravel, and it appears as if there was either a general erosive event across the site that stripped the Early Holocene deposits, or simply that it was not an accreting environment at that date. Peat or organic muds formed across the site above the gravel terrace at varying altitudes ranging from -6.17m OD in BH1 to -2.88m OD in BH4. The formation date for this deposit is variable, with 5300-4850 cal BC at the lowest altitude and a gap of approximately a thousand years before the organic mud in BH4 developed, from 4300-4000 cal BC, but at a higher altitude in this location. It is possible that there is no clear trend in age against altitude across the site with the date from BH4 being inconsistent owing to the raised altitude. Furthermore, the peat in BH1 (closest to the river) began forming from 4500-4200 cal BC whilst it might have reasonably been expected to begin formation later than

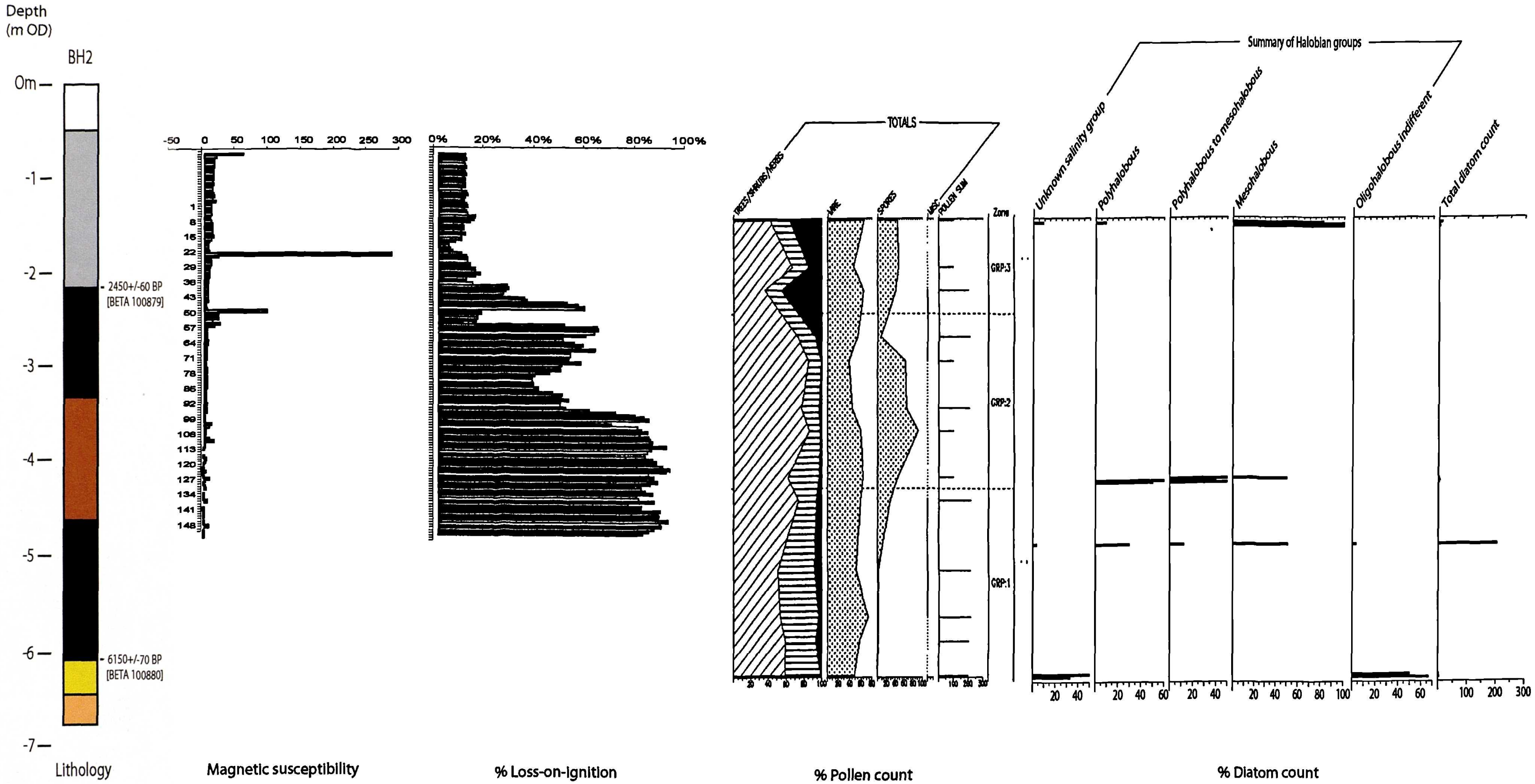



Figure 62. Gallions Reach summary diagram

the peat further away from the river, although it could be being forced by a rising watertable associated with RSL rise. Nevertheless, the peat in BH8 also forms at approximately the same date as that in BH4 (4300-4000 cal BC), but 0.5m deeper. There are likely to have been problems of differential peat compaction across the site reflecting the variability in the altitude of the gravel. Nevertheless, it is possible to say that the peat formation occurred relatively consistently across the area from the Late Mesolithic period.

Several of the boreholes contain two peat horizons, but the more common pattern is for the formation of one large peat bed. Where there are two (BH2 and BH6), they are in the centre of the site and possibly affected by an infilling early palaeochannel; furthermore, the lower peat is quite thin, and certainly, on the basis of the pollen in BH2 (see Figure 62), seems to reflect initially an alder carr, which formed under a predominantly freshwater regime. This might reflect conditions in and adjacent to an abandoned channel. However, diatom samples from the top of this lower peat indicate that by this date the site is in contact with the estuary, suggesting a fairly rapid ecological change. The subsequent break in organic formation in the centre of the site may reflect re-activation of a north-south palaeochannel, becoming a tidal creek, which subsequently led to localized mineral sedimentation only found within the area of the channel. This could explain why no break in organic formation is seen elsewhere at this level. The peat remains wood-rich throughout, with the pollen record from BH2 indicating consistent alder carr with mixed deciduous woodland nearby. However, diatom samples within the peat show the site remained in contact with the estuary and was subject to inundation of brackish water, indicating that the peat formed under conditions of locally rising RSL. The peat appears to cease forming across the site between -3.45m (BH3) to -1.57m OD (BH4), with a date of 2300-2000 cal BC in BH4.

The organic muds above the peat contained few diatoms, but those present indicate continued domination by the tidal Thames, probably with extensive mud flats and some low marsh. This is particularly clear at the southern edge of the site. The pollen record shows possible evidence for clearance and agriculture nearby, and local alder carr. The date for the submergence of the organic mud is slightly unclear with ranges from *c.*1700-1300 cal BC at -1.7m OD and 800-400 cal BC at -2.2m OD. The presence of purely mineral sediment over the site in all locations indicates that by the Bronze/Iron Age transition, the entire area was submerged and probably in-channel, at least north of BH4 and BH3.

The stratigraphy at Gallions Reach has proved to be relatively simple, with the Shepperton Terrace sealed initially by freshwater sediment with a gradually strengthening marine signal changing to peat formation in the very Late Mesolithic. There is some variation in the peat deposits across the site, with a period of interruption in one location, thought to have occurred as a result of palaeochannel re-activation. The peats, although indicative of well-developed wetland communities, remained in contact with the estuary, suggesting a period of continued (but reduced) RSL rise. The replacement of the peats by organic estuarine muds shows an increase in the rate of RSL rise from approximately the end of the Neolithic, *c.* 2400 cal BC. The area then appears to have remained on the boundary of the wetland/intertidal interface for much of the Bronze Age until the site was finally inundated in the Late Bronze Age/Early Iron Age.

Stratigraphically, the sequence is similar to that recorded by Spurrell (1885) at Crossness where he defined an organic rich gravel and two peat horizons, with the estuary having reached the site before peat formation. Devoy's (1979) logs are more complex but the general trend and dating are comparable with the sequence from Gallions Reach.

# Chapter 7. North Woolwich Pumping Station, London Borough of Newham, E16 (TQ 4345 7985)

## 7.1 Introduction

### Site Location

North Woolwich Pumping Station (code WW-PS93, GLSMR 062294, 1 on Figure 63) is located on the north bank of the River Thames to the west of the Royal Victoria Gardens, adjacent to North Woolwich railway station in the London Borough of Newham (see Figure 63). North Woolwich is bounded by the Thames to the south and east, by the King George V (2 on Figure 60) dock to the north and Silvertown (3 on Figure 63) to the west. The modern setting is given over primarily to industrial and transport facilities, with industrial estates and warehouses in the vicinity, in addition to a train line, the Woolwich ferry terminal and the London City airport (4 on Figure 63). Prior to development, the site was a disused goods yard associated with the railway. The development scheme here was to construct a water pumping station and pipeline.

### Previous Research

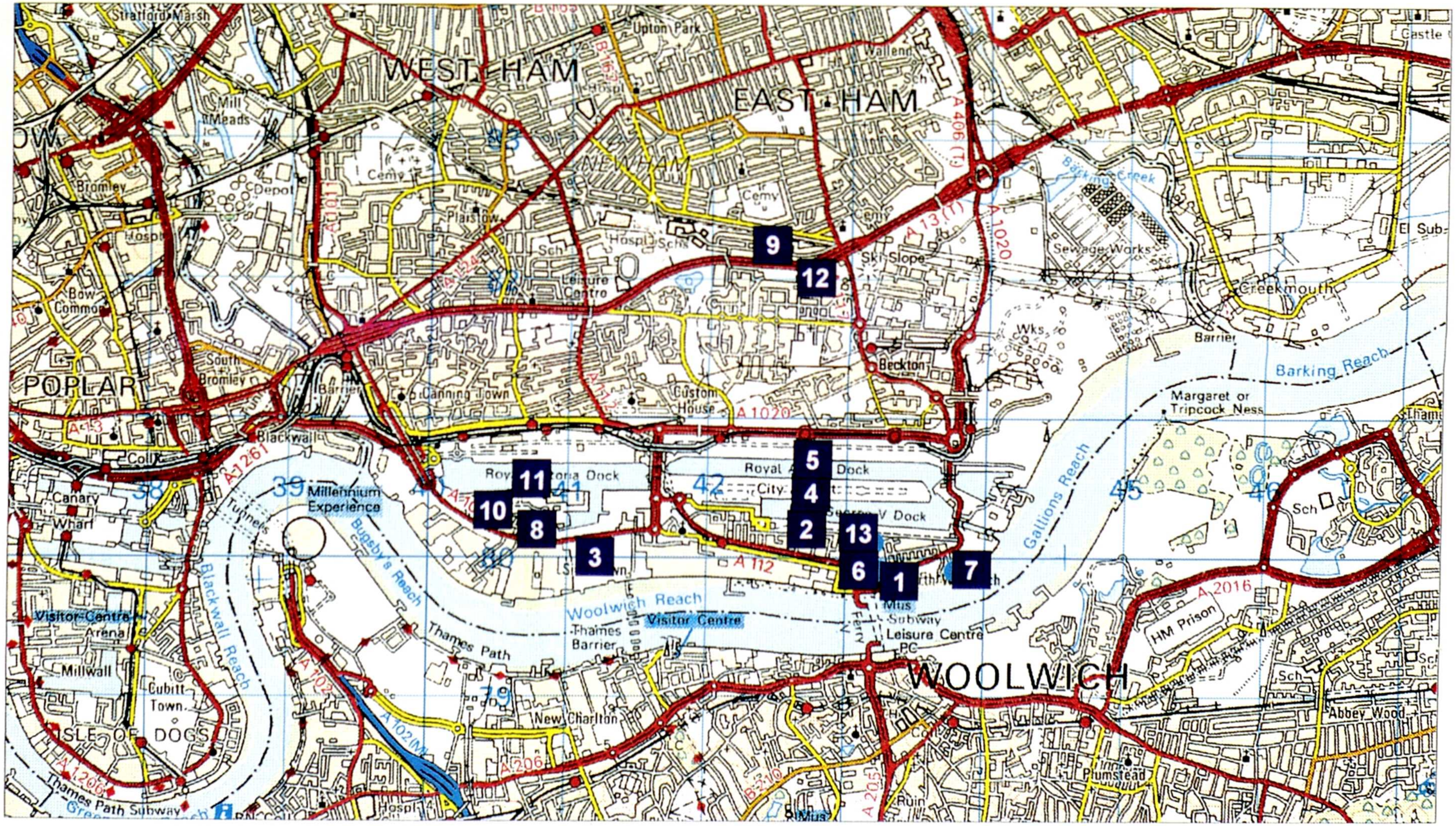
North Woolwich has shown a consistent sedimentary sequence consisting of Pleistocene gravel (Shepperton Terrace) at c. -5m OD overlain by interdigitating organic (often described as 'woody peat') and minerogenic deposits sealed beneath several metres of modern overburden. Spurrell (1889) noted oak, yew, hazel and birch trees recovered from peats excavated during the construction of the Royal Albert Dock (5 on Figure 63) along with *Bos primigenius, Castor fiber* (beaver) and *Capreolus capreolus* (roe deer). Recent work at 145-55 Albert Road (Spurr 2001, 6 on Figure 63), just to the north east of the site found such a sequence with gravel overlain by organic muds and clays dating from *c.* 6000 to 3000 radiocarbon years BP. Elsewhere, possible palaeochannels within the Holocene sediments have been inferred running to the east of the pumping station site (Truckle and Tamblyn 1991). A project at Bargehouse Road (Corcoran 2001, 7 on Figure 63) to the east proposed a model of Late Mesolithic wooded soils forming over the Pleistocene gravel which were sealed by alternating peats and inorganic sediment thought to represent alder carr and mud flats. The sequence is believed to persist here until the late medieval/post-medieval period when the area was inundated by the River Thames once more. Small areas of high sand and gravel have also been observed within the general area, notably at Fort Street, Silvertown (Crockett et al. 2003, 8 on Figure 63) and at Woolwich Manor Way (Whittaker 2001, 9 on Figure 60). The sequence at both these sites reflects the general trend of gravel sealed by a combination of organic and inorganic sedimentation.

Only limited investigation of RSL change has occurred in the area. Work thus far has centred on Silvertown urban village (Wilkinson et al. 2000, 10 on Figure 63) and is discussed in Chapter 8. At Bargehouse road (Corcoran 2001), it has been suggested that the alternating peat and mineral sediment represent oscillations in RSL, with the sequence starting to form *c.* 6800 radiocarbon years BP. The investigations at Woolwich Manor Way (Whittaker 2001) suggest that the minerogenic sediment within the sequence formed under rising sea level, but the data are not analyzed in any detail.

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | North Woolwich Pumping Station | 4345 | 7985 |
| 2 | King George V dock | 4275 | 8030 |
| 3 | Silvertown | 4125 | 8000 |
| 4 | London City Airport | 4275 | 8049 |
| 5 | Royal Albert Dock | 4275 | 8060 |
| 6 | Albert Road | 4325 | 7990 |
| 7 | Bargehouse Road | 4380 | 7990 |
| 8 | Fort Street | 4077 | 8020 |
| 9 | Woolwich Manor Way | 4249 | 8220 |
| 10 | Silvertown Urban Village | 4050 | 8035 |
| 11 | Royal Victoria Dock | 4075 | 8055 |
| 12 | Beckton | 4270 | 8200 |
| 13 | Milk Street | 4320 | 8010 |

Table 20. Sites shown on Figure 63

The area's heritage is currently protected through designation as an archaeological priority zone designated with the Newham UDP. Chance finds from the area include Palaeolithic handaxes (GLSMR 060582, 060581) from the Victoria (11 on Figure 63) Dock construction to the north and a Bronze Age palstave and 'rapier' from the Royal Albert Dock (GLSMR 061759, 061751). Relatively little excavation has been undertaken in the area, but what has been recovered is highly significant.




0.6 0 0.6 1.2 1.8 2.4 3.0 Kilometers

Figure 63. Location map of North Woolwich Pumping Station and other sites mentioned in this chapter

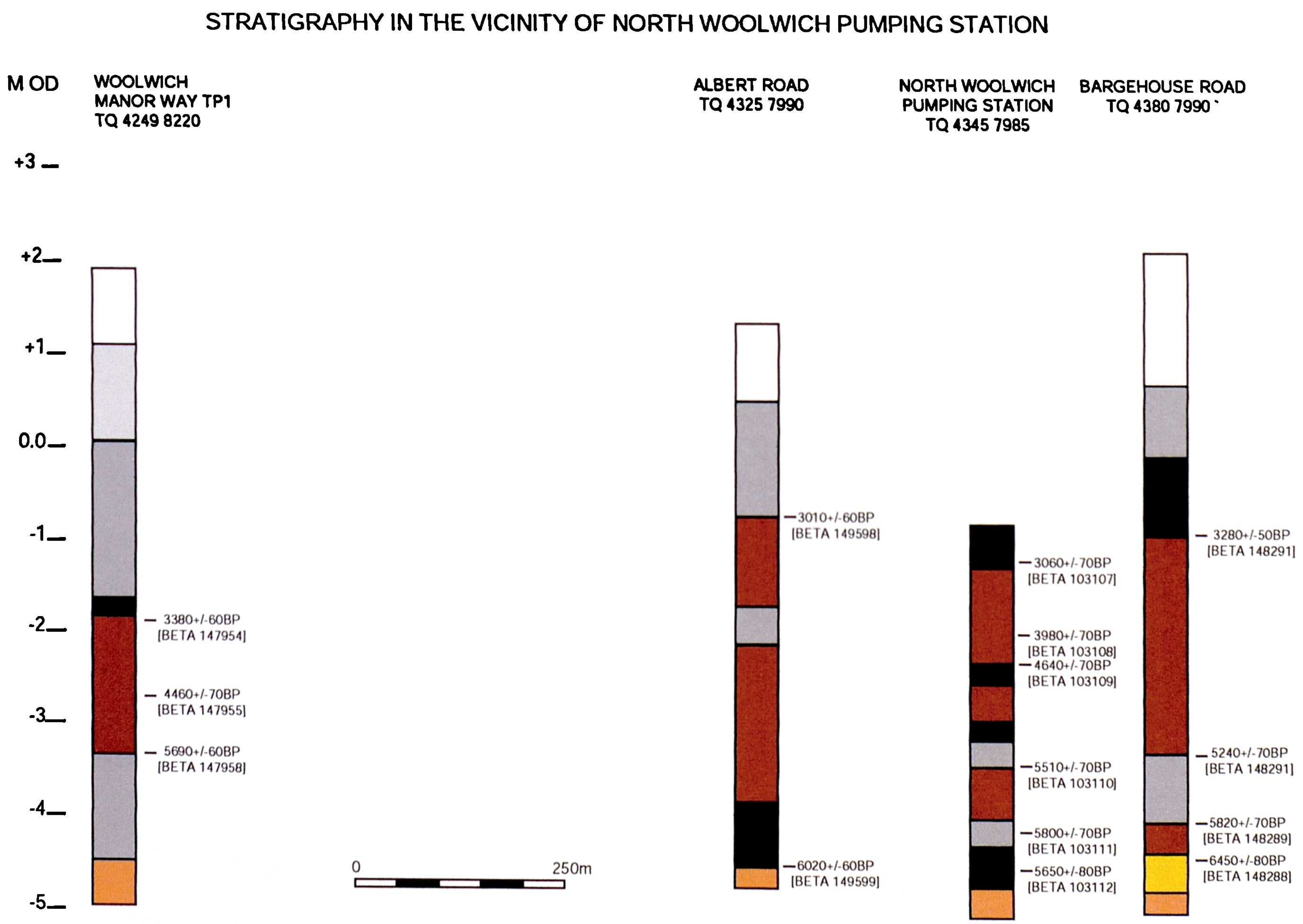



Figure 64. Stratigraphy in the vicinity of North Woolwich Pumping Station. See Figure 91 for key

Current work on the A13 at Woolwich Manor Way (Whittaker 2001), *c.*1.5km to the north of the pumping station site has revealed an Early Neolithic site, with features, ceramics (Mildenhall Ware), struck flints (including an arrowhead, several scrapers, piercers and flakes) and large quantities of cereal grain, all on a slightly elevated piece of ground above the floodplain. There is also a mid- Bronze Age phase with trackways, worked wood and a possibly curated Beaker. To the west, at Fort Street, Silvertown, an excavation revealed a Neolithic timber trackway of alder and ash plank construction (Crockett et al. 2003) found within Neolithic peat. Although a number of Bronze Age trackways are known locally from Beckton (12 on Figure 63), a Neolithic one is extremely rare. Ceramics and worked flints were also associated with the structure. At Bargehouse road, Corcoran et al. (2001) suggest that an undated prehistoric timber trackway may have been present on the site at c. -4.0m OD based on a large quantity of roundwood within one of the boreholes drilled on site. Roundwood trackways are known from Bronze Age deposits at Beckton, to the northeast. Cereal pollen was also recorded within the peats here, suggesting local arable cultivation. Such pollen was also recovered from Albert Road (Spurr 2001) and again concluded to represent cultivation nearby, rather than directly on site.

Roman occupation deposits and debris have been found to the northeast of the site at Milk Street (GLSMR 062640) (Corcoran 2001) (13 on Figure 63) and at Woolwich Manor Way (Whittaker 2001). A Roman canoe (3rd century AD) (GLSMR 060208) was recovered during the construction of the Royal Albert Dock in the 19th century; Spurrell additionally noted Roman black pottery and Samian ware, with food debris and tiles at approximately 3m below surface in the 1878-9 period of dock construction. Evidence for medieval manor houses has been discovered near to Albert Road (GLSMR 061803), thought to be part of the manor of *Hammarsh*, owned by Westminster Abbey. This appears to have been destroyed by floods in 1236 (Powell 1973). There is further evidence for a later medieval settlement in North Woolwich, until it was flooded in the early 15th century (Truckle and Tamblyn 1994). Brick fragments at the top of the peat/clay interface at Albert Road are considered possible evidence of this settlement (Spurr 2001) whilst medieval ditches have been discovered at Woolwich Manor Way (Whittaker 2001).

## The Project

An archaeological project monitored the removal of sediment from a substantial coffer-dammed area prior to location of new pumping machinery and a pipeline. An archaeological condition was placed upon the works, with allowance for sampling to reconstruct the palaeoecology and depositional environment of the site, as well as to examine any *in situ* archaeology. The samples were collected from an intact sedimentary stack (see Figures 65-67) using overlapping stainless steel monolith tins.

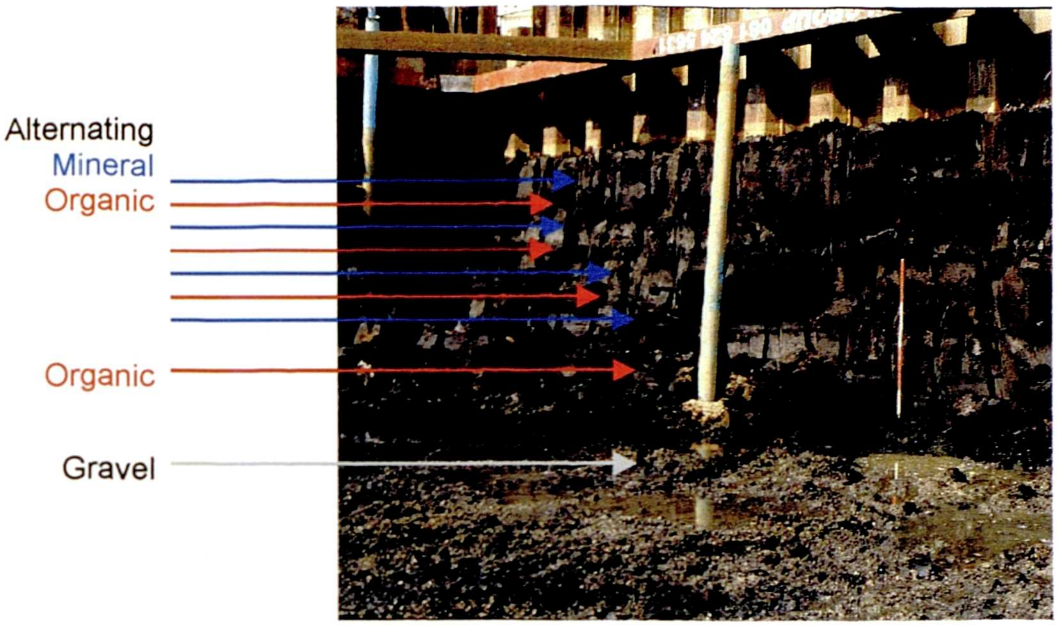



Figure 65. Section at North Woolwich Pumping Station (2m scale)

Preliminary examination of the sequence indicated a complex depositional cycle, with peats, silts and organic muds overlying the basal gravel, whilst an assessment of the microfossils indicated reasonable preservation of diatoms and pollen. Initial radiocarbon assay showed a relatively long-lived sequence of *c.* 3300 years with an apparent hiatus between the gravel and the first organic sedimentation.

On the basis of these initial findings, the site was selected for analysis to examine:

- *The sedimentary processes acting upon this site*
- *The vegetation history and depositional environments present on site*
- *Mid-Holocene sea-level tendencies in this location*
- *Whether the site compares with the Devoy (1979) model*

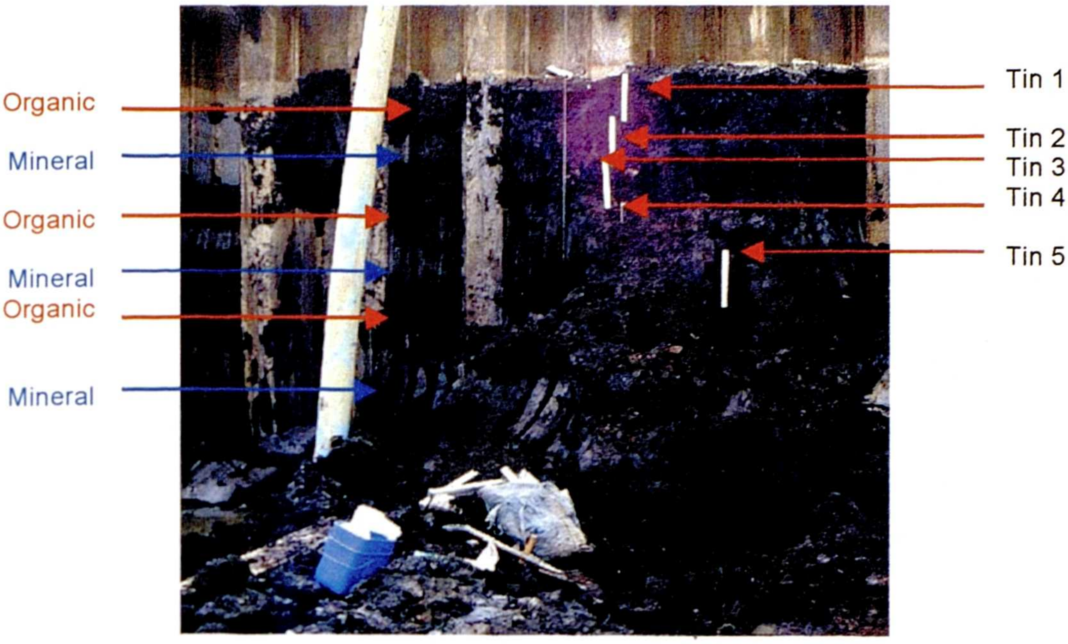



Figure 66. Upper samples in section at North Woolwich Pumping Station

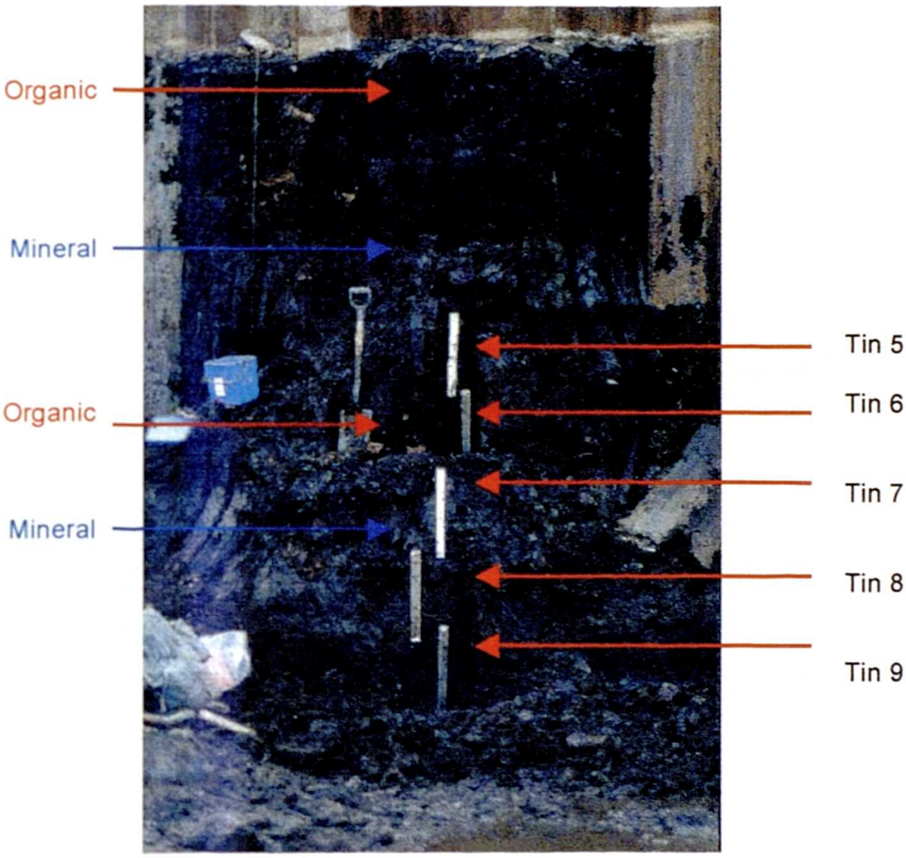



Figure 67. Lower samples in section at North Woolwich Pumping Station

## 7.2 The Sequence

The sequence consists of Pleistocene gravel sealed by two substantial organic bands interdigitating with three minerogenic bands. At the interfaces between the mineral and organic, organic muds are present (see Figure 68). Full details may be found in Appendix 4.

NORTH WOOLWICH PUMPING STATION (TQ 43457985)
LITHOLOGICAL DIAGRAM

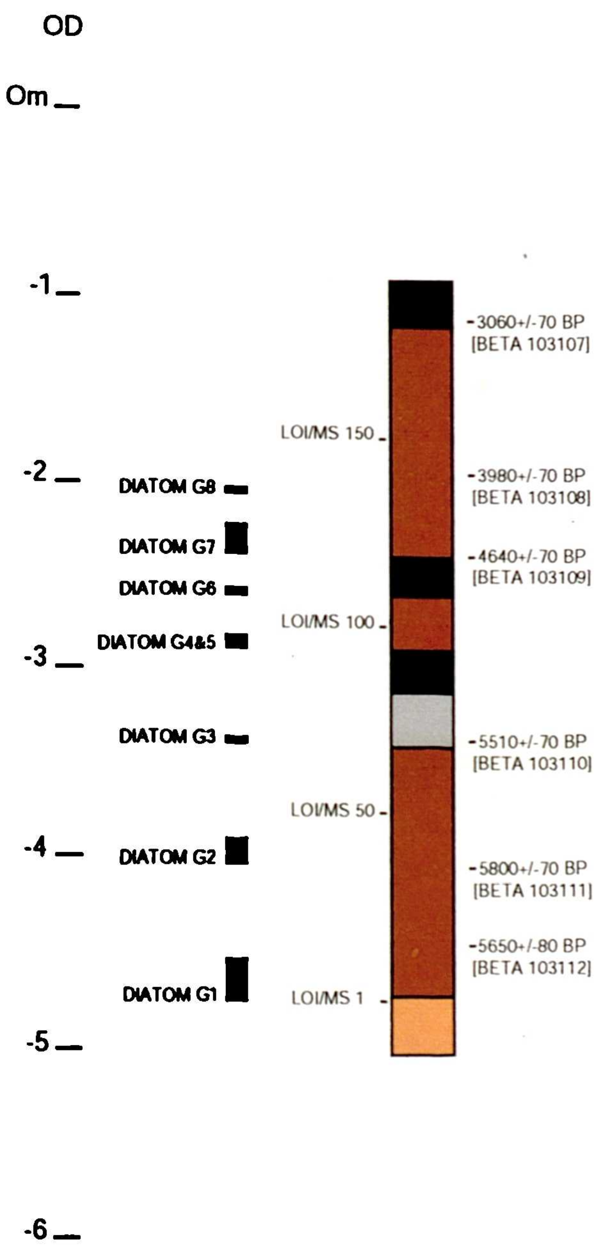



Figure 68. North Woolwich Pumping Station lithological diagram. See Figure 91 for key

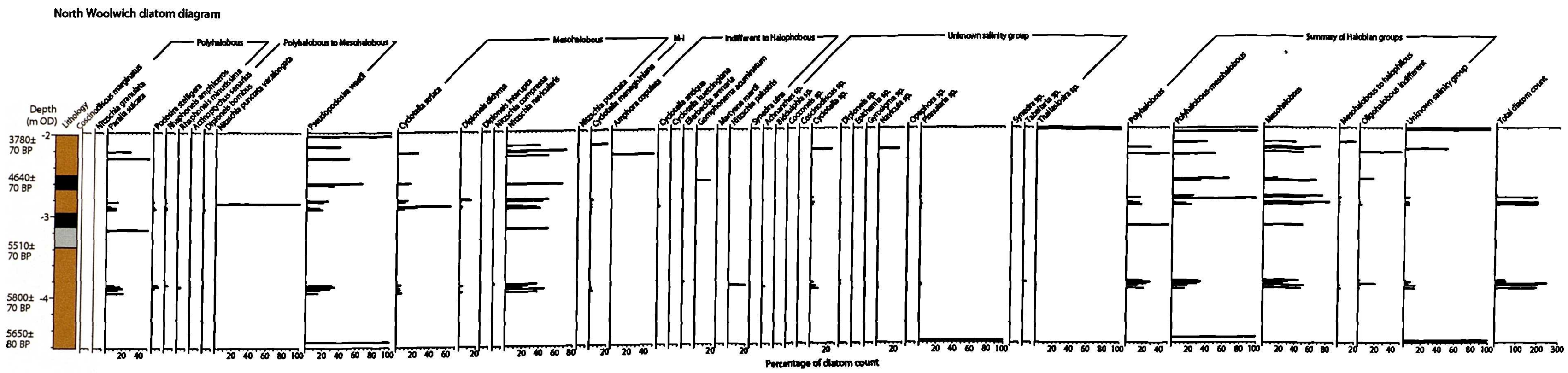



Figure 69. North Woolwich Pumping Station diatom diagram

Sands and gravel of the Shepperton Terrace underlie the site at *c.* -5.0m OD (see Appendix 4, Lithology). There is no evidence for a palaeosol on the Pleistocene gravels; rather a fining upwards sequence within the top of the sand and gravel suggests that the site was located mainly within the Devensian river channel. Evidence from elsewhere in the Thames suggests that a decrease in flow rates, probably dating to the Early Holocene followed the gravel accumulation of the Devensian Late Glacial (Wilkinson et al. 2000).

The gravels are sealed by a silt-clay containing gravel clasts almost certainly derived from the Shepperton Terrace. The sequence demonstrates a fining up trend from this point and for the first time small amounts of unidentifiable organic material is incorporated within the mineral deposit. Iron staining was noted at this level, and may indicate that the site was exposed to sub-aerial weathering at this point. This could also reflect a hiatus in the sequence. However, the characteristics of this minerogenic group change, with a coarsening of the sediment type and further gravel clasts embedded within a clay-silt. Unfortunately, only a few diatom valves were preserved within this deposit (*Pinnularia* sp. and *Pseudopodosira westii*) (see Appendix 4, Table 66). Such small numbers suggests harsh preserving conditions, and the combination of these two species, which apparently reflect freshwater and marine conditions, is unusual.

The mineral deposits are sealed by the first organic deposit, recorded above -4.74m OD and initially consist of an organic mud, with silt-clays, degraded undifferentiated organic material and also a reasonably well-preserved wood component. The lowest point which yielded enough material (*c.* -4.5m OD) dated to 5650±80 BP (Beta 103112; 4690-4340 cal BC). This date supports the suggestion of a break in sequence between the deposition of the gravel and this point. Magnetic susceptibility values ($\chi^{f}$) are low within this deposit (see Appendix 4, Figure 62), correlating with the inwash of mineral sediment. Analysis of pollen samples from this level (see Figure 70 below) to the contact with the subsequent sedimentary deposit has shown the predominant contemporary environment to be an alder carr with hazel (see Appendix 4, section 4.3). There is also evidence for elm, oak and lime woodland, but presumably slightly to the north on drier ground. This is likely to be on the East Tilbury Marshes Terrace, mapped *c.* 2km to the north on the British

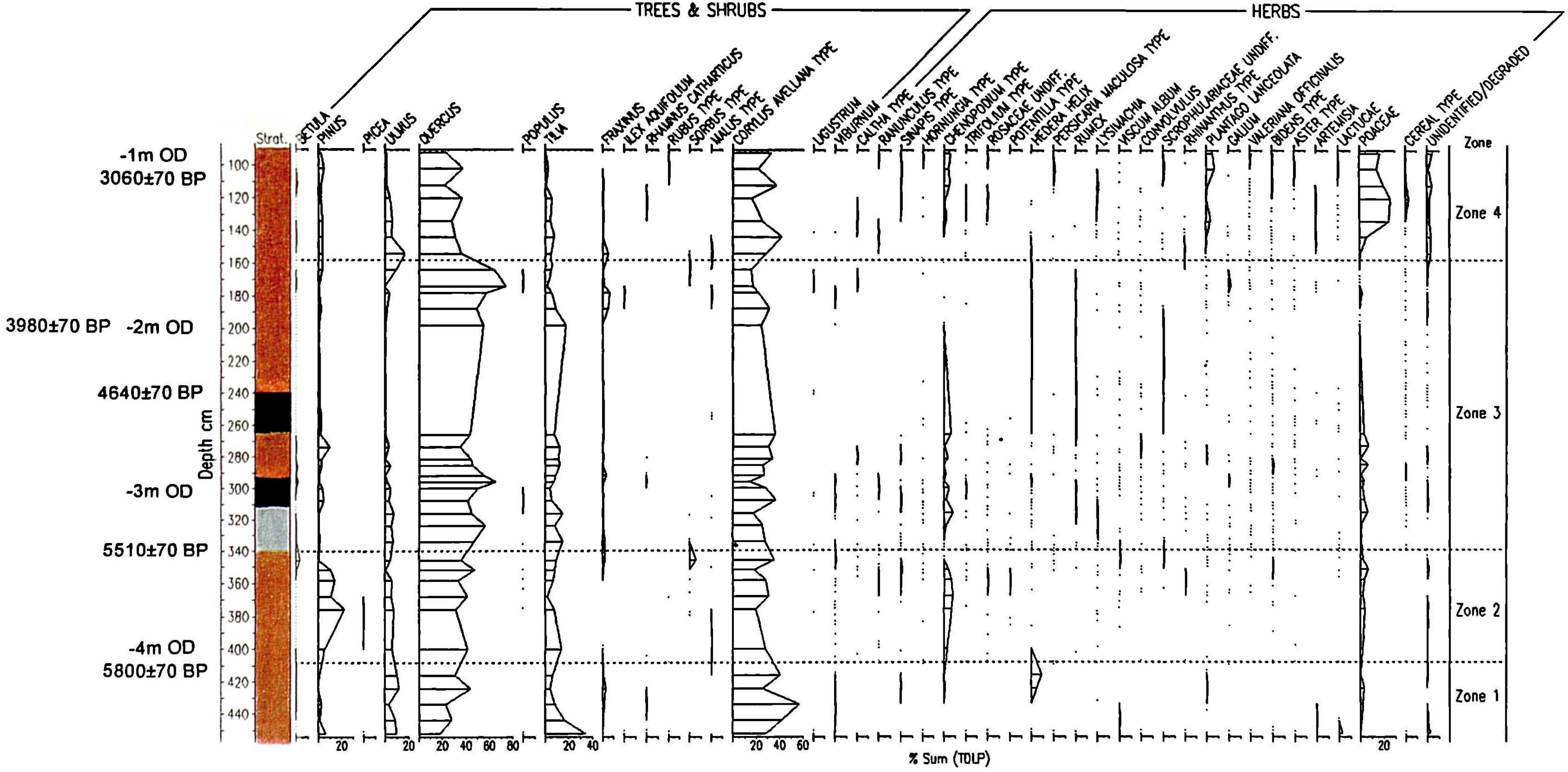
Geological Survey 1:50,000 sheet 257. The presence of elm within this woodland community is important, as this record is a relatively late occurrence. In the London basin elm decreases dramatically from *c.* 5500 BP (termed the primary elm decline (see Sidell et al. 2000, chapter 8)). Pine was also present and this is significant in that it is not generally recorded within the London flora at this stage within the Holocene. Usually it is recorded only in the Early Holocene (Rackham and Sidell 2000) and has disappeared by the Late Mesolithic. Interestingly, it is also noted from Albert Road, slightly to the northeast (Spurr 2001) at this date. The alder carr developed in a period when the main channel briefly migrated away from the sampling site enabling vegetation to expand locally. The percentage of organic carbon does not exceed 70% within this deposit (see Appendix 4, Figure 163), which formed rapidly with the radiocarbon dates for the top and bottom being statistically indistinguishable.

A thin band of silt clay within the peat contains a low proportion of organic detritus. The interface between these deposits (*c.* -4.1m OD) dates to 5800±70 BP (Beta 103111; 4830-4460 cal BC). The $\chi^{r}$ values drop from the previous deposit and therefore continue to be very low. Diatom samples (14-19, -4.01-3.91m OD) from this interface show much better preservation than encountered lower down the profile. The lowest sample is dominated by *Nitzschia navicularis* and *Paralia sulcata* with a reasonable amount of *Pseudopodosira westii.* A series of *Cyclotella* sp. valves were identified but too damaged to be confidently assigned to species level. Nevertheless, these species indicate that deposits associated with tidal conditions accumulated during the Late Mesolithic. The ecological groupings of Vos and de Wolf (1993) to which these species belong include the *Navicula digitoradiata* group; i.e. benthonic, epipelic species potentially indicating local clayey sediments of the intertidal/subtidal zone. *Diploneis didyma* as well as *Nitzschia navicularis* was found here and is a representative of this grouping. A second ecological group indicated at this interface is the *Paralia sulcata* group of marine planktonic and semi-planktonic, representing marine littoral and tidal inlet and channel environments. In addition to a significant presence of *P. sulcata* (nearly 25% total valve count), this assemblage also includes *Pseudopodosira westii.* The *Cyclotella striata* group is also represented (estuarine plankton of tidal channel environments) with *C. striata, C. meneghiniana* and *Cyclotella* sp. making up a fifth of the assemblage. There are a few valves of *Pinnularia* present and although they may be derived, there is a possibility that they represent local freshwater input, or exposed mudflats above the tidal limit. Overall, the assemblage appears to indicate sedimentation on tidal flats with some possible freshwater input.

The situation changes with sample 17; the *P. sulcata* group species obtain over 50% of the total valve count whilst *N. navicularis* and the *C. striata* groups decline against this. This may show some fluctuation in the location of the intertidal zone at this point, although the increase of *P. sulcata* could possibly be explained by salt marsh expansion. Although not fully counted (owing to poor preservation), the two remaining samples across this transition indicate a continuation of *N. navicularis* and *C. striata* dropping in relation to the *P. sulcata* group signal. The increased damage to diatoms and the changing sedimentary conditions may support the suggestion of wetland expansion indicated in the sedimentary record.

The pollen samples from this deposit show a sharp decrease in *Alnus,* which can be accounted for by the change in sedimentation (from broadly semi-terrestrial to estuarine) above -4.1m OD. The appearance of *Chenopodium* type and Cyperaceae indicates that although the environment was much wetter, there was still the possibility of local vegetational development, although the river may have washed these in. Interestingly, the arboreal element of the spectra continues relatively unchanged with elm, oak and lime, with pine still part of the assemblage.

Woolich WW PS93



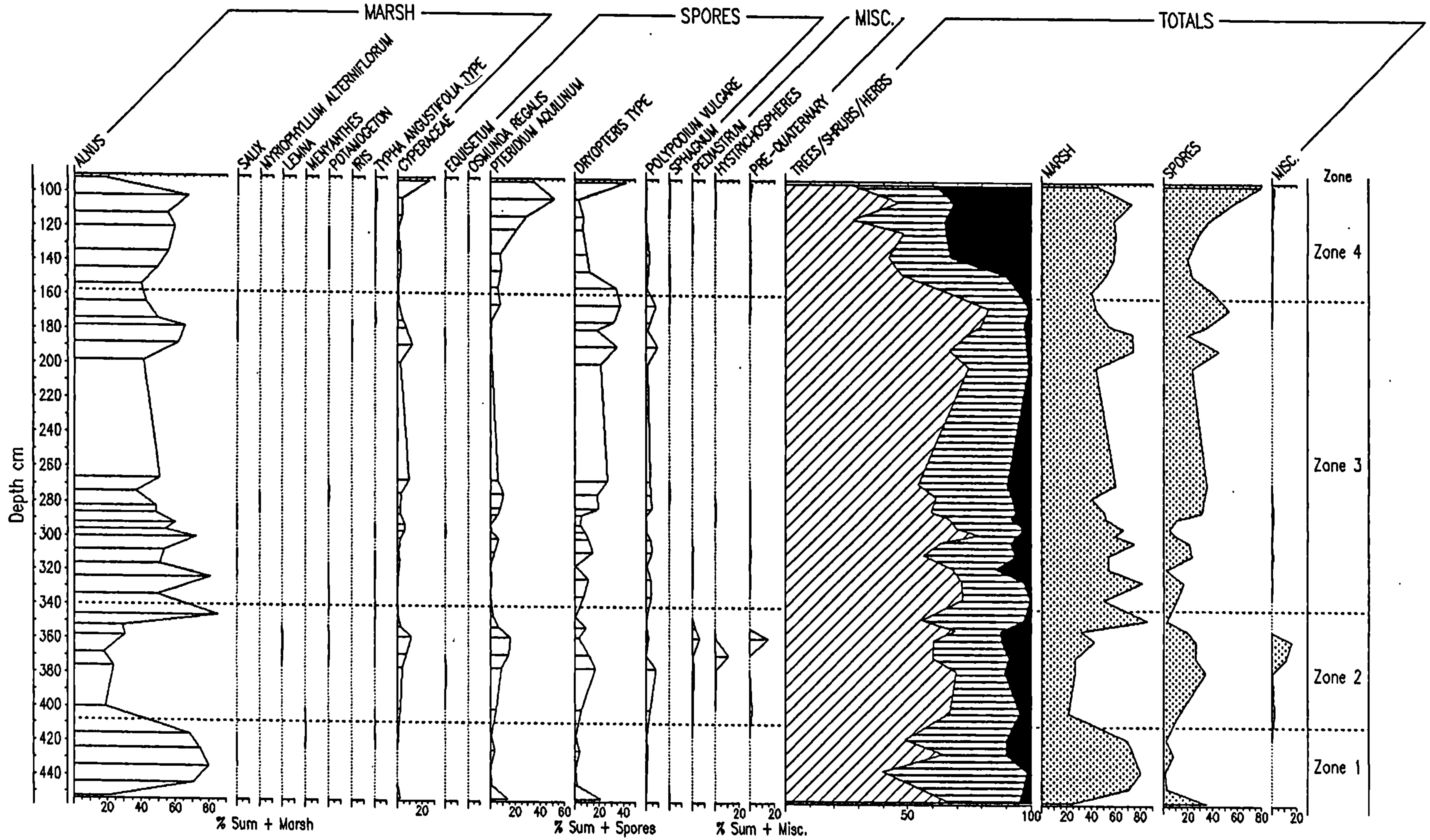



Figure 70. North Woolwich Pumping Station pollen diagram (by Dr. Rob Scaife)

The site seems to have been in an inter- or sub-tidal position for several hundred years until the next substantial semi-organic semi-terrestrial surface starts forming at the Mesolithic/Neolithic transition. From *c.* -3.6m OD, the sequence reverts to organic sedimentation, consisting almost entirely of humified organics with only a few traces of wood. Some fine grained clastic material was present in the lower levels of this organic deposit, but this gradually ceased with the development of a fully organic sediment, initially composed of degraded material and large quantities of wood, which persist for *c.* 150mm when the peat changes to a reed-dominated deposit to *c.* -3.4m OD. Pollen data indicate that the alder carr expands with further evidence for drier ground nearby supporting elm/oak/hazel/lime woodland. The continuing presence of elm is important because it is from this date that the species begins to be eradicated from the pollen record across London. This is considered to be a result of initial woodland clearance by the human community and subsequent devastation by the elm bark beetle, *Scolytus scolytus* (Girling and Greig 1985; Girling 1988).

This is succeeded by a further change in sedimentation to waterlain deposits; a silt-clay with small amounts of humified organic matter, woody fragments and sand. The contact to these minerogenic deposits is gradual and non-erosive, but the small organic traces within the mineral matrix are likely to have been redeposited from these or local organic beds. The contact between the organic and mineral sediment at this altitude (*c.* -3.4m OD) dates to 5510±70 BP (Beta 103110; 4490-4170 cal BC). The organic muds demonstrate a fining up tendency, suggesting that the velocity of flow that lead to the initial inundation was not maintained. More organic mud starts forming from *c.* -3.1m OD; roughly half mineral, half highly degraded organics. The $\chi^{r}$ values are erratic throughout this deposit, although they are all low. It suggests that there is much variation on a micro scale, corresponding with the organic/minerogenic fluctuation. Diatom samples from this altitude (-2.98-2.95m OD) indicate estuarine conditions; the *Navicula digitoradiata* and *Paralia sulcata* groups of Vos and de Wolf (1993) form over 80% of the assemblage in the lowest sample, with a small proportion of *Cyclotella* species. However, *Cyclotella striata* increases dramatically in the upper samples, which may indicate a reduction in intertidal mudflat type environment and a likely submersion of the site.

The organic component within the sedimentary sequence increases from *c.* -2.9m OD. The $\chi^{lf}$ values show that some mineral sediment is present throughout as values are comparable with the previously mineral dominated sediment and do not get close to zero, which are values more typical of totally waterlogged degraded organics. Pollen samples indicate that alder dominates, whilst cereal type pollen and *Plantago lanceolata* grains were recorded from -2.92m OD in conjunction with a woodland element. These are not likely to represent on-site growth, but nearby vegetation. The main point of interest in the pollen record from this level is the cereal pollen, which may indicate the presence of a local human community that has cleared areas of land and given them over to arable cultivation. Although this has not been directly dated, it is likely to have occurred in the middle of the fourth millennium cal BC on the basis of the dates above and below this level in the sequence. This is relatively early for London where much cultivation does not appear to begin until the Bronze Age (Yates 2001).

The evidence from the diatom record indicates that once again the *Navicula digitoradiata* and *Paralia sulcata* groups are about equally represented, whilst the *Cyclotella striata* group species again only form approximately 10% of the assemblage. This organic mud is sealed by inorganic silt-clays and then once again more organic mud to *c.* -2.4m OD. Woody fragments are present within these muds. Only a few diatom valves were found; presumably a result of poor preservation. The species represent tidal conditions (for instance *Pseudopodosira westii)* but no detailed inference may be drawn.

This phase of sedimentation persisted for between 300 and 1400 calendar years when the second major organic deposit starts forming at *c.* -2.4m OD, dated to 4640±70 BP (Beta 103109; 3630-3100 cal BC). The deposits are highly degraded, although wood and some plant fragments are recognizable. Samples from the lower part of the peat were examined for diatom content but preservation was very poor with only a few valves observed. These again indicate marine/brackish conditions with species such as *Pseudopodosira westii, Nitzschia navicularis* and *Paralia sulcata,* possibly suggesting local mud flat and salt marsh formation; however, no conclusions should be drawn from so few valves. Preservation of the organic material improves up the profile, with stems and rhizomes of herbaceous and woody plants visible. Some iron staining may be indicative of some oxidation and drying within this peat, which is over a metre thick. It is sealed from *c.* -1.1m OD, by an organic mud that is degraded, although woody fragments were observed. The contact between the peat and the overlying organic mud was dated to 3060±70 radiocarbon years BP (Beta 103107; 1440-1130 cal BC) indicating the phase of peat formation was long-lived; in the order of 1100-1700 years. Pollen from the organic muds suggests increased ground water levels with a significant increase of *Pteridium aquilinum* (bracken) and *Chenopodium* type. However, cereal type, Poaceae and *Plantago lanceolata* also increased, to the detriment of the arboreal taxa. Sampling ceased at this point owing to modern contamination within the upper deposits, which were noted as grey silt clays.

## 7.3 Site Summary

The sedimentary history is relatively complex at North Woolwich, with a fluctuating series of processes driving sedimentation. These range from initial (Mesolithic) mineral sedimentation thought to derive from the Thames, probably under freshwater conditions, to Late Bronze Age estuarine sedimentation with intervening periods of semi-terrestrial alder carr development (see Figure 71).

The first evidence of sea-level movement comes with a transgressive overlap dated to 5800 BP at -4.1m OD. This continued for several hundred years until a series of organic muds and peats formed, interleaved within estuarine mineral sediment. There is no evidence for an actual drop in river level and it may be that the organic deposits represent the major phase of estuary contraction identified by Long et al. (2000). This has been taken to indicate a drop in the rate of sea-level rise but not a drop in actual sea level relative to the land. The lack of freshwater diatoms throughout the sequence at North Woolwich suggests that the trend was of an upward movement, but with oscillations in the rate.

There is a significant break in the middle of Neolithic organic accumulation lasting for at least 300 years which seems likely to have occurred as a result of rising relative river levels. If so, this phase could be seen as a period of accelerated relative river level rise, slowing in the Late Neolithic, as shown by further sea-ward expansion of the peat beds which lasted for over a thousand years before river levels before a final transgressive overlap in the Late Bronze Age.

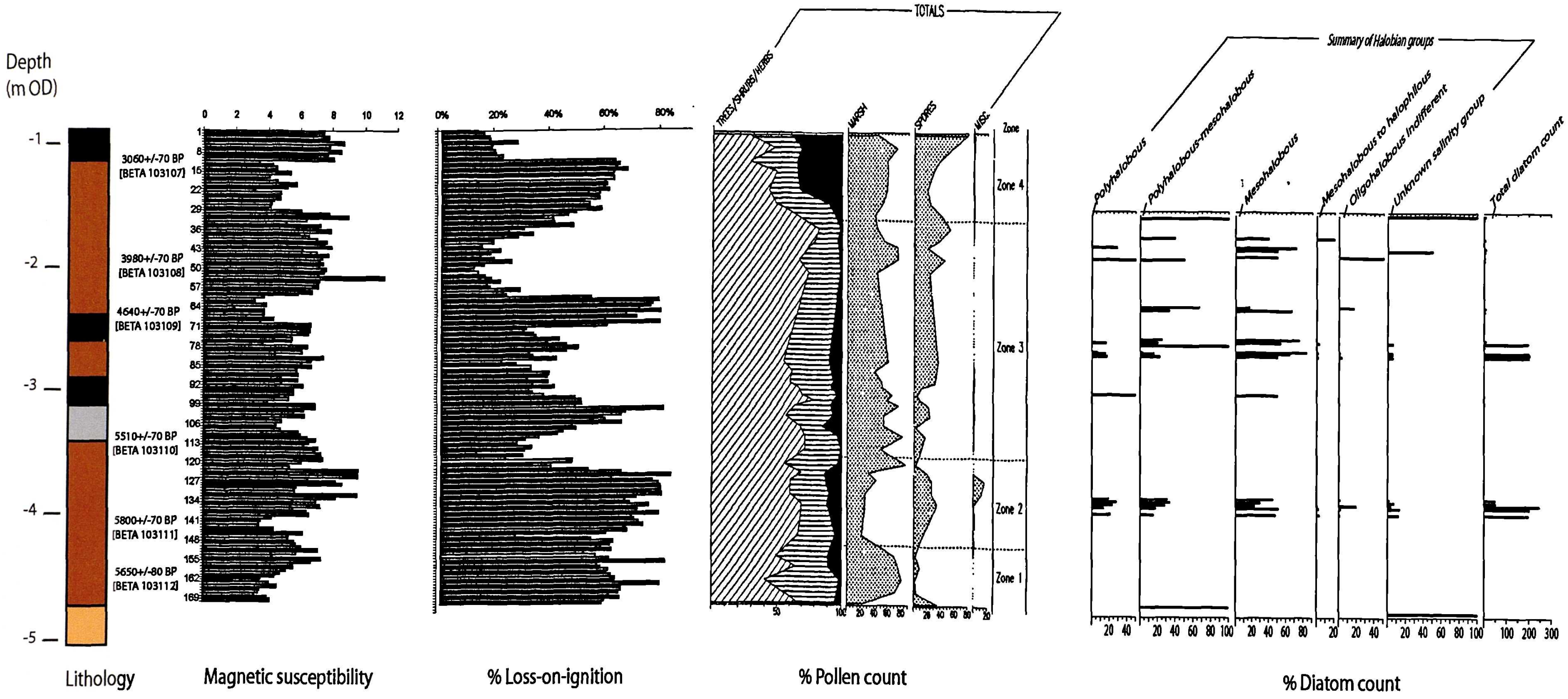



Figure 71. North Woolwich Pumping Station summary diagram

# *Chapter 8. Silvertown Urban Village, Royal Victoria Docks, London Borough of Newham E16 (TQ 4050 8035)*

## 8.1 Introduction

### Site Location

The site (code BWC96, GLSMR 062650) is located in Silvertown on the north bank of the Thames (1 on Figure 72), east of the Greenwich peninsula (2 on Figure 72) and directly to the south of the Royal Victoria Dock (3 on Figure 72). It is bounded to the east by Fort Street (4 on Figure 72) and to the west and south by Silvertown Way and North Woolwich Road (5 on Figure 72). The development where the cores were taken was within the Silvertown Urban Village and the specific estate is known as Barnwood Court. Previously the site was used for warehouses whilst the general area has been heavily industrialized, with docks directly to the north and factories, an oil depot, a brewery and sugar refining all occurring in the immediate vicinity. The area is currently being re-generated with housing, sports facilities and an exhibition centre but with little riverside development to date.

### Previous work

There has been relatively little investigation of the stratigraphy in this area. An antiquarian source describes sections in the Royal Victoria Dock as containing over three metres of peat reaching nearly to the gravel, as well as many trees (Blandford 1854). Geotechnical surveys carried out in advance of house building at Silvertown urban village suggested the presence of two peat deposits, which were correlated with Devoy's Tilbury III and IV (Hawkins 1995). A borehole evaluation on North Woolwich Road (GLSMR 066642) proved a sequence of estuarine clay silt tentatively dated to the Roman and post-Roman period (however, no absolute dates were obtained and the period is suggested on the basis of the pollen) (Keeley et al. 1997). Two boreholes were drilled by the Geoarchaeology Service Facility (GSF) at Fort Street (Pine 1994) which encountered gravel at between -2.25 and -4.0m OD overlain by sands, in some places, up to 2.0m deep. Peats and organic muds occurred between -3.6m OD and 0.10m OD, overlying the sands.

Interestingly the basal contact to the sands drops from south to north, i.e. away from the river. Fine gained minerogenic deposits overlie the peats and are truncated by the modern overburden. The peat sequence here dates to the mid Holocene, 4470±70 BP (Beta 76205; 3360-2920 cal BC, -2.1-2.0m OD) and 3390±90 BP (Beta 76206; 1920-1450 cal BC, -0.8-0.45m OD). The subsequent excavations at Fort Street (Crockett et al. 2002) confirmed this sequence. Another phase of development at Silvertown urban village uncovered a sequence of mid Holocene peat and organic muds, which have also been correlated with the Tilbury III phase of the Devoy (1979) model, whilst later silt clays were dated to the Late Iron Age (GLSMR 062650, Farid 1997).

No significant work has been done on reconstructing sea level from data gathered in this area. As noted above, several archaeologists have correlated their sequences with the Devoy (1979) model, but this has not involved thorough analysis but has simply been done on the basis of finding large peat horizons, often undated and without reference to the biostratigraphy.

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Silvertown Urban Village | 4050 | 8035 |
| 2 | Greenwich peninsula | 3925 | 7975 |
| 3 | Royal Victoria Dock | 4075 | 8055 |
| 4 | Fort Street | 4077 | 8020 |
| 5 | North Woolwich road | 4080 | 8010 |

Table 21. Sites shown on Figure 72

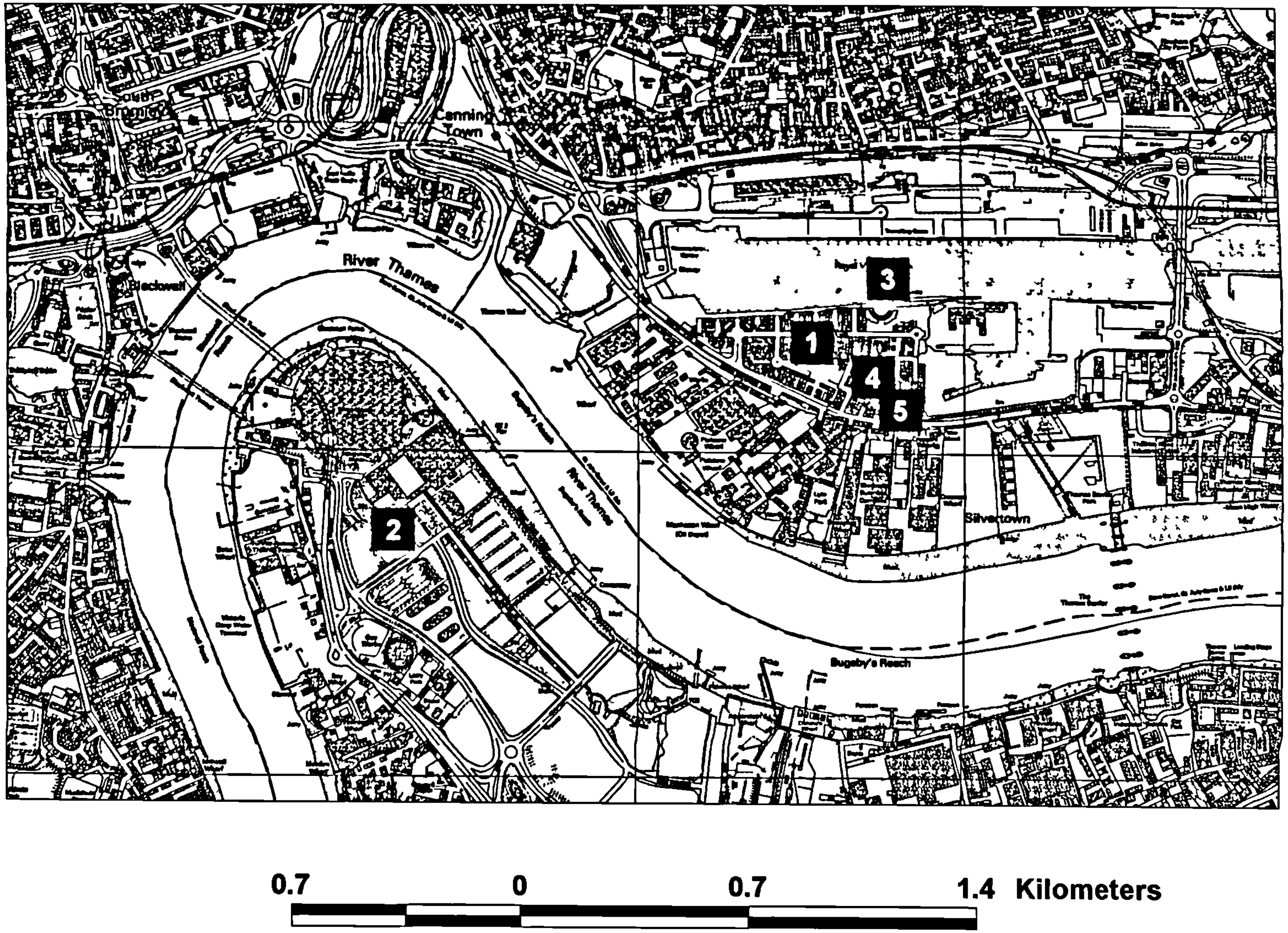



Figure 72. Location map of Silvertown Urban Village and other sites mentioned in this chapter

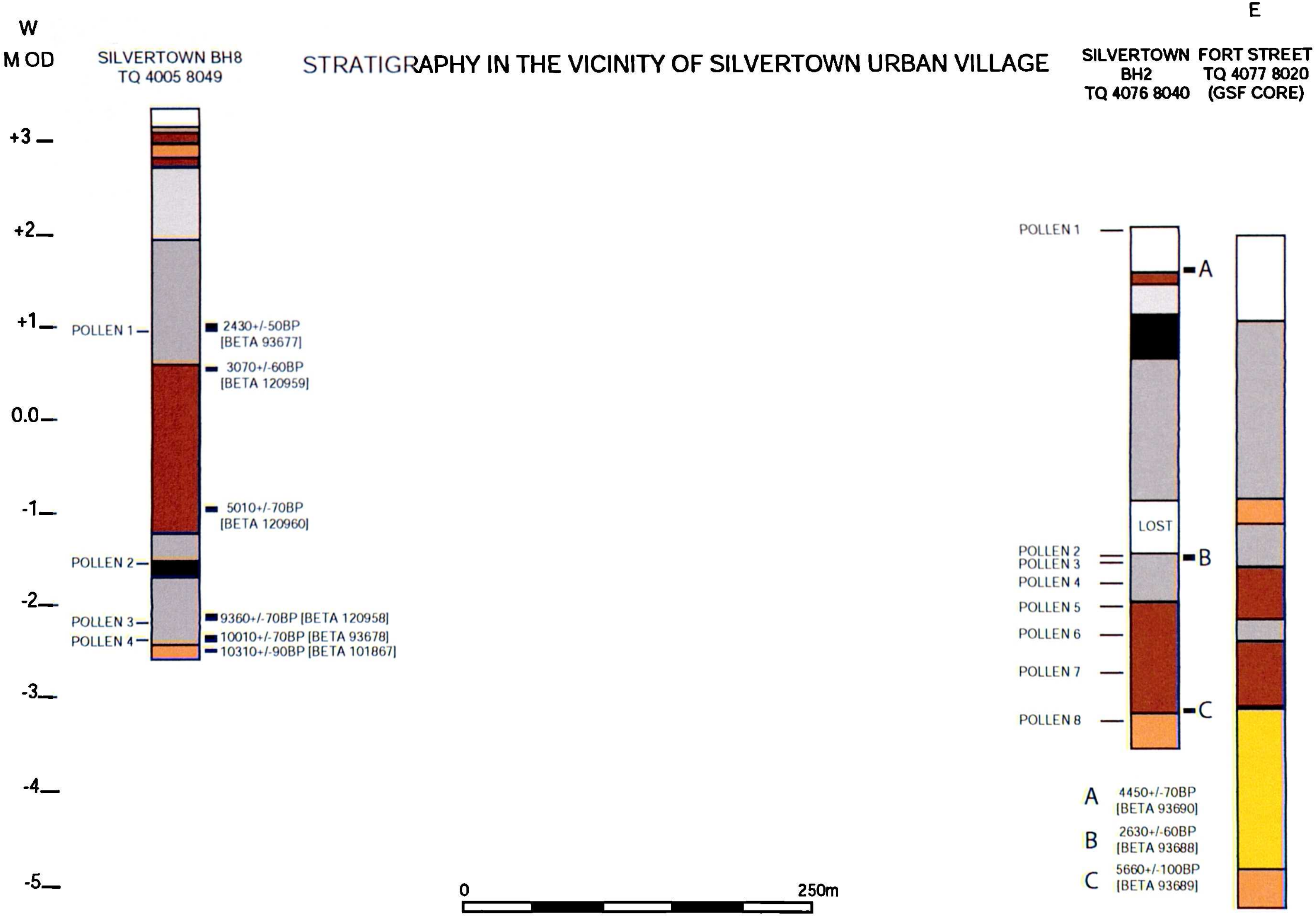



Figure 73. Stratigraphy in the vicinity of Silvertown Urban Village. See Figure 91 for key

There is no archaeological tradition in this area, probably a result of the heavy industrial use of the area. Isolated artefacts have been found, such as several Palaeolithic axes recovered during construction of the Royal Victoria Dock (GLSMR 061758, 060582), a Bronze Age palstave also from the dock construction (GLSMR 061759), along with less well provenanced material including a medieval bowl from the Thames (GLSMR 108000). Recent excavations at Fort Street, directly to the east of the Barnwood Court complex, revealed a plank built Neolithic trackway (GLSMR 062137) (Crockett et al. 2002) running north south on a sand bar. Later Bronze Age pottery and flint was also found. This is a rare and unusual find in that the London prehistoric trackways are generally Bronze Age and not plank-built (Meddens 1996). With regard to the historic period, there is very little available information, with limited records of an early medieval manor house (Sudbury *alias* abbey place) (GLSMR 061790) just to the northeast of the site (Powell 1973), which persisted until at least the 16th century.

## The Project

An archaeological project was undertaken in the summer of 1996 to evaluate the land in advance of housing development. Seven boreholes were drilled (BH1 was abandoned due to contamination) using a cable percussion shell and auger rig (see Figure 74). U4/100 samples were collected from seven boreholes, from undisturbed sequences. The location of all boreholes was recorded and leveled in. The samples were sealed and transferred to the Museum of London.

An assessment (*sensu* MAP2) was carried out which indicated relatively complex stratigraphy of peats and waterlain silt clay across the site. The initial radiocarbon dating showed some Early Holocene sedimentation, a rare survival in the central London floodplain. A further unusual survival was some medieval deposits; such late material is often heavily truncated by modern intrusions such as basements and services. Assessment of the biostratigraphy showed very poor diatom preservation but reasonable pollen survival. On the basis of the assessment, the site was selected for inclusion in this project, but the terms of the commercial project and planning condition required conventional publication, which was recently finalized (Wilkinson et al. 2000). The criteria for inclusion in this thesis were:

- *The central position relative to other sites in the project*
- *The large number of samples and complex stratigraphy*
- *Late Devensian/Early Holocene sediments giving a longer sequence than usually encountered*
- *The opportunity to examine Holocene sea-level tendencies*
- *Good chronological data*
- *Reasonable biological preservation*

## 8.2 The Sequence

The cores were all described and then BH8 was selected for detailed lithological and pollen analysis (see Appendix 5 for details). The general sequence is of Pleistocene gravel overlain by Early Holocene peat, a hiatus to mid Holocene peats and then later silt clays with a sand bar at the eastern end of the site. A localized thin peat dating to the medieval period was also found below spoil from the dock construction.

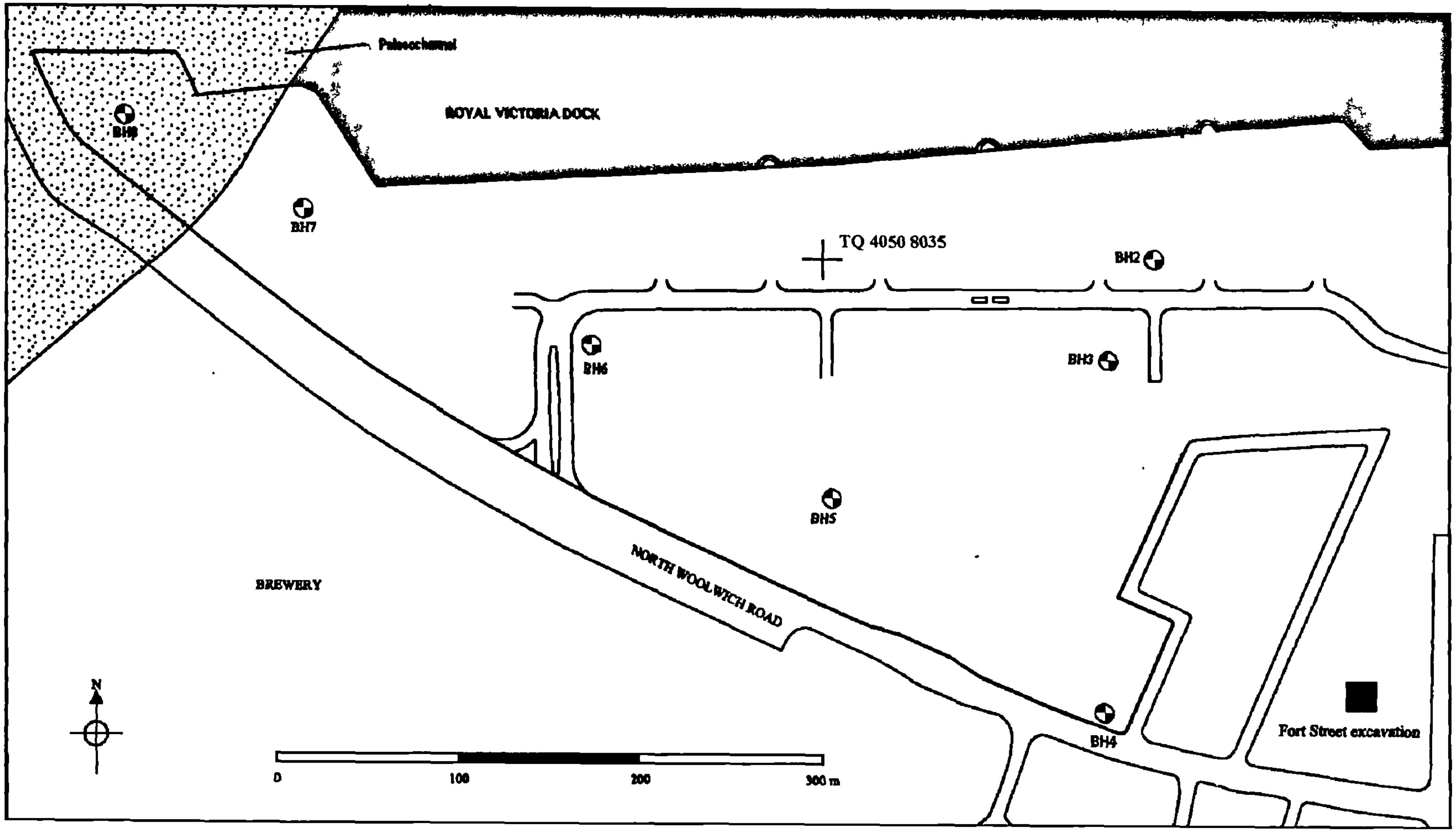



Figure 74. Silvertown Urban Village site outline and borehole location plan

SILVERTOWN URBAN VILLAGE (TQ 4050 8035) LITHOLOGICAL DIAGRAM (BH2 - 4)

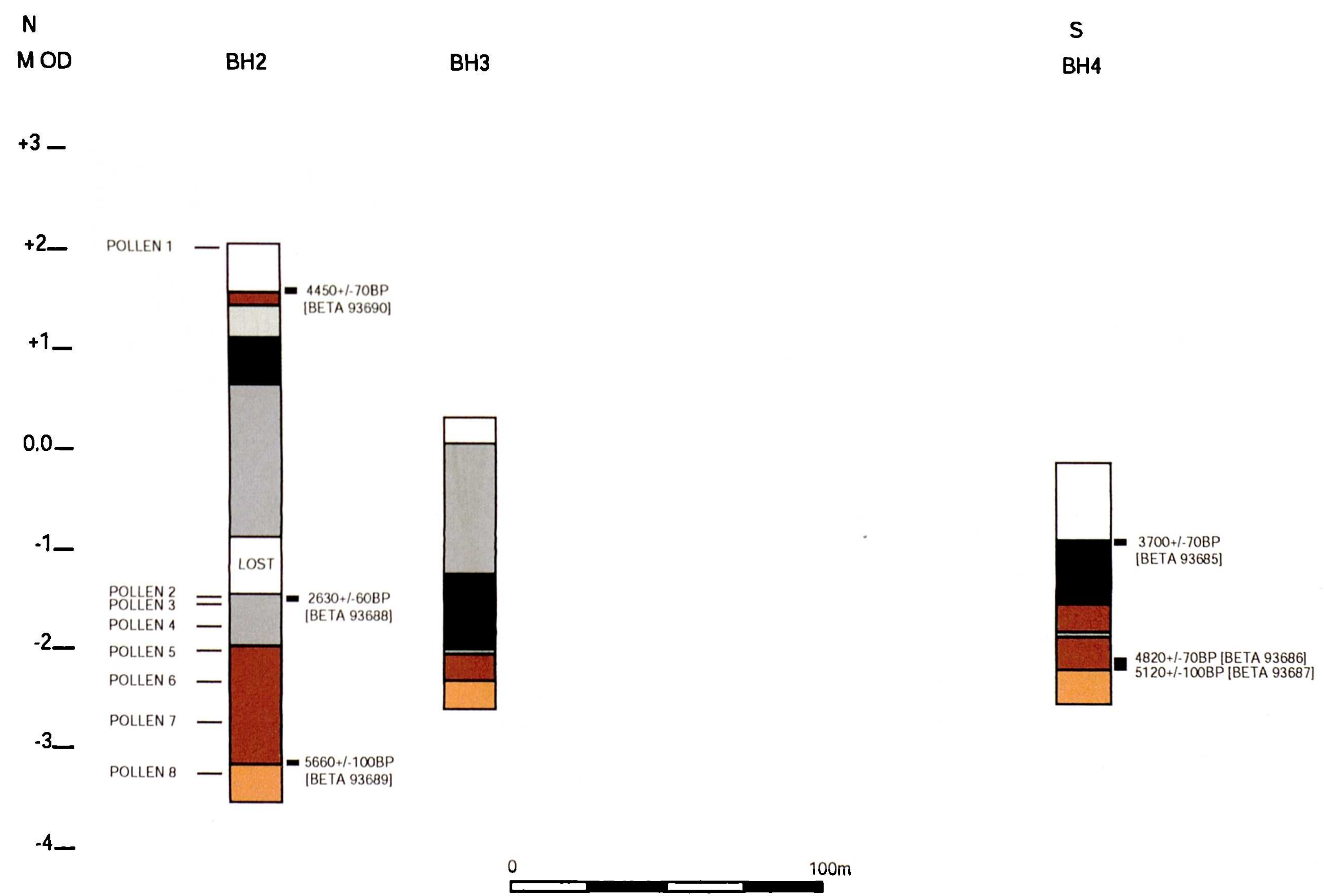



Figure 75. Silvertown Urban Village lithological diagram, BH2-4. See Figure 91 for key

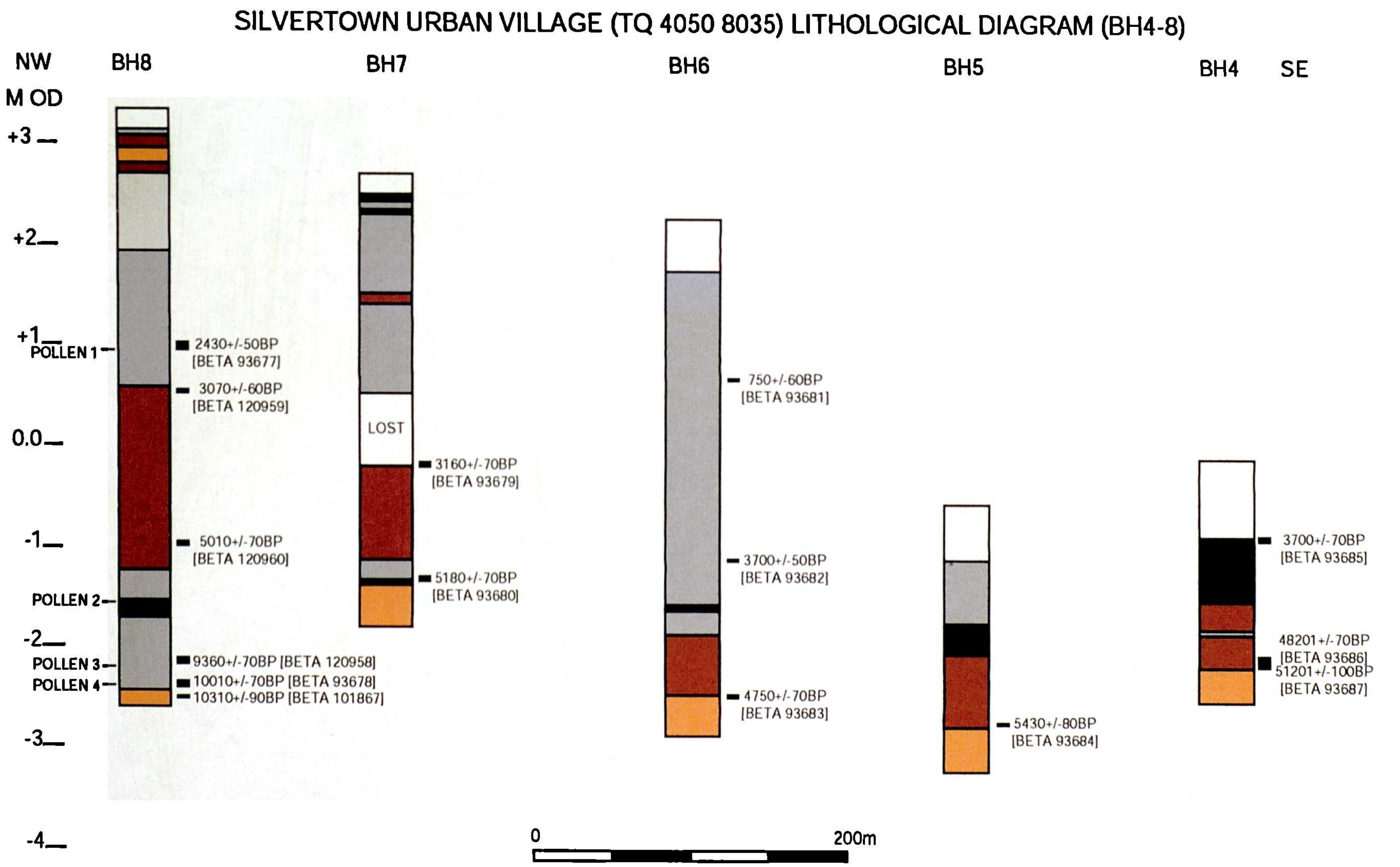



Figure 76. Silvertown Urban Village lithological diagram, BH4-8. See Figure 91 for key

## BH2

The upper surface of the Shepperton Terrace occurs at *c.*-3.46m OD and consists of sand and gravel with some silt and degraded organic material in the uppermost levels, at *c.* -3.2m OD (see Appendix 5, Lithology). This organic material dates to 5660±100 BP (Beta 93689; 4770-4330 cal BC, -3.30 to -3.26m OD) (see Appendix 5, Table 76), the later Mesolithic, which suggests a hiatus in deposition from the Devensian when the gravel was lain down. It is sealed by a substantial peat deposit; highly degraded with only a few woody fragments and a low proportion of mineral sediment. The upper levels were weakly laminated with an upward increase in the mineral content. From -1.91m OD the sequence becomes mineral dominated with some degraded woody fragments and undifferentiated organic matter within the matrix. The lower mineral deposits were weakly laminated, showing a continuation from the laminated sediments in the underlying peat horizon, suggesting that the change in formation occurred very gradually in a low-energy environment. A scan of pollen from between -3.26 and -1.47m OD indicates reasonable preservation with trees and shrubs being the dominant classes of vegetation present (see Appendix 5, 5.3 and Figure 77). Key species include *Quercus, Tilia, Alnus* and *Corylus avellana* type with lesser representation of *Betula, Pinus, Ulmus* and *Fraxinus.* Cereal is present at -2.75m OD along with *Plantago lanceolata* and Poaceae, which may indicate cereal cultivation being undertaken nearby. Although no date is available at this level, it falls between the Late Mesolithic and Middle Bronze Age; in depth it is closer to the Mesolithic horizon and could potentially represent Neolithic cultivation. *Ulmus* reaches a peak at -2.04m OD and is only sparsely present thereafter; potentially this could indicate the primary elm decline, which has been tracked across London at *c.* 5500 BP (Sidell et al. 2000). A radiocarbon date was obtained (-1.45 to -1.49m OD) from organic material to examine accumulation rates, giving a result of 2630±60 BP (Beta 93688; 930-540 cal BC) placing this into the Late Bronze Age/Early Iron Age transition.

There was a hiatus in the sequence at this point, with oxidized clay silts present from -0.88m OD. Small amounts of degraded organic material were incorporated towards the top of this deposit, at +0.65m OD. The organic content gradually increases from this point, but does not persist beyond +1.08m OD where a slightly coarse mineral deposit was recovered (contact was unfortunately lost in the cutting shoe, so it is unknown whether this was an erosive contact). The coarseness of the mineral component increases to the extent that some gravel was recovered within the matrix. From *c.* +1.4m OD the deposit becomes more fine grained and contains degraded organic traces and a large piece of wood, again in a poor state of preservation and truncated by the modern fill. A radiocarbon measurement was obtained for the piece of wood but appears to be anomalous at 4450+70 BP (Beta 93690; 3350-2920 cal BC) indicating some reworking within the sequence. A pollen assessment indicates similar species and percentages to the lower peats in this borehole and it is possible that the deposit is dumped spoil from dock construction (this borehole is very close to the Royal Victoria Dock).

### BH3

The contact with the Shepperton Terrace is at -2.325m OD and is overlain by a black woody peat with a low clay content; some moss was present, suggesting that although occasionally flooded, the surface was largely terrestrial with moss growing in a wooded environment, possibly on trees. The peat was sealed at *c.* -2.0m OD by thin mineral band and then an organic mud containing highly humified organic debris and some wood fragments. The organic content increases although it remains highly humified. The mineral content increases at -1.24m OD, indicating increased frequency of flooding across the site. The final deposit in this borehole is a silt clay; the organic content has completely disappeared, indicating that by this point the site is inundated more or less continually, nevertheless, iron staining in the clays suggests that it is periodically exposed allowing oxidation of the sediments to occur. Modern fill is present at +0.115m OD.

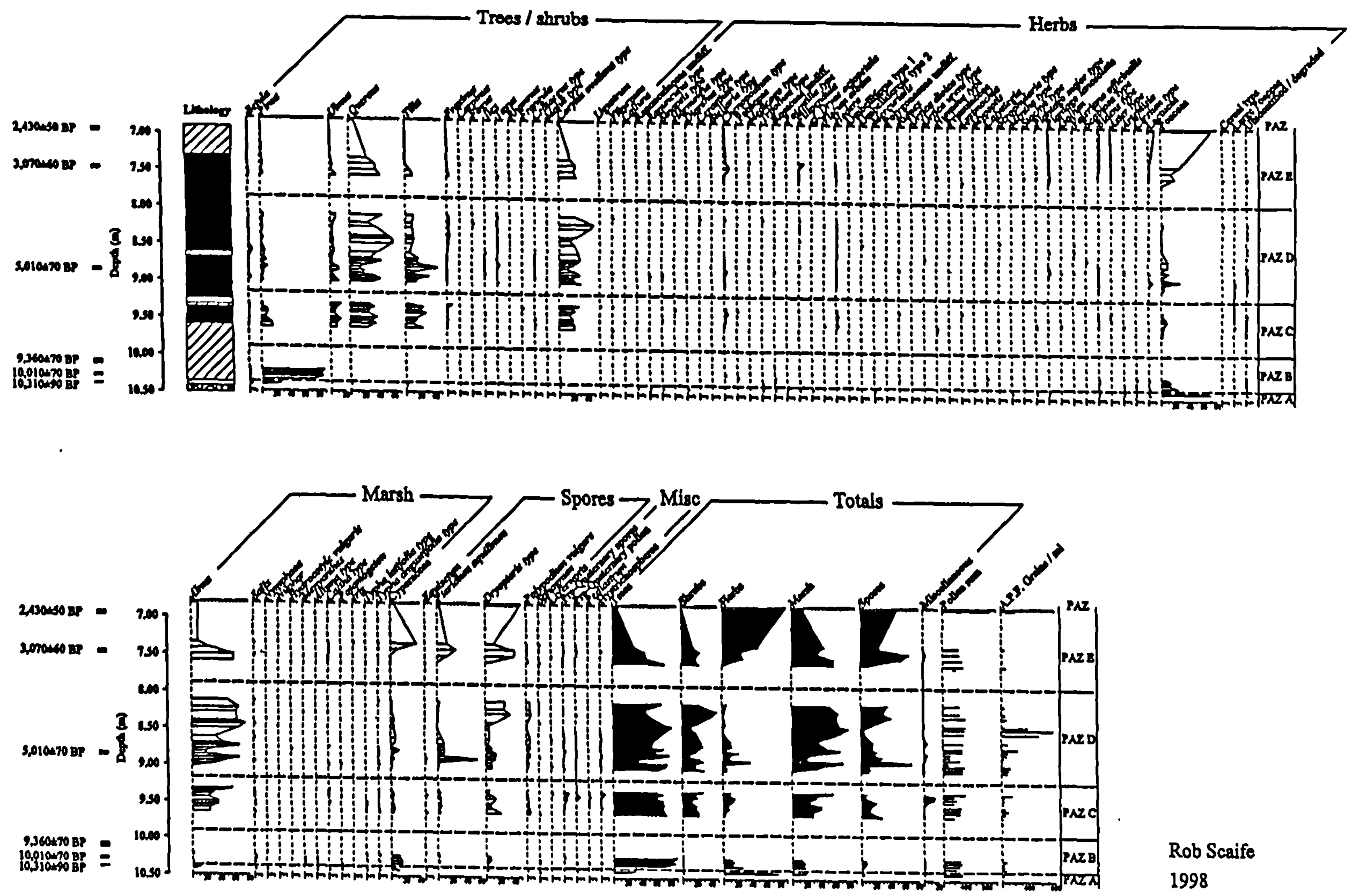



Figure 77. Silvertown urban village pollen diagram by Dr. Rob Scaife, from Wilkinson et al. (2000)

### BH4

Sand and gravel of the Shepperton Terrace was present below -2.48m OD, containing some wood fragments as well as a small proportion of clay silt. It was immediately overlain by a very dark brown, primarily organic deposit, almost entirely humified but with a few traces of herbaceous plant fragments. Two radiocarbon measurements have been obtained from this deposit to establish the date and examine the rate of formation. The lower contact (-2.18 to -2.12m OD) gave a result of 5120±100 BP (Beta 93687; 4230-3690 cal BC) whilst the subsequent sample (-2.12 to -2.08m OD) dated to 4820±70 BP (Beta 93686; 3760-3370 cal BC). This peaty sediment persists until -1.83m OD where it was sealed by 50mm of silt clay with no obvious inclusions. Neither the upper or lower contacts of this silt clay showed sign of erosion. Organic sedimentation resumes at -1.78m OD, but with a higher mineral component than prior to the flood event, suggesting that the site flooded with greater frequency than before, leading to the formation of organic mud with a low proportion of humified material and occasional wood fragments. This deposit persists to -0.84m OD where it is sealed below modern overburden. The upper contact of the organic mud dates to 3700±70 BP (Beta-93685; 2290-1880 cal BC); the Early Bronze Age.

### BH5

Gravel is present below -2.8m OD and is overlain by black peat composed of highly humified material with occasional fragments of wood and herbaceous plants. Small gravel clasts and sand are present at the contact between the gravel and peat. The lowest datable material (-2.77 to -2.75m OD) gave a result of 5430±80 BP (Beta 93684; 4450-4040 cal BC). This points to a significant hiatus in the sequence as deposition of the Shepperton Terrace is thought to have occurred between 15-10000 years ago (Gibbard 1985). Peat formation persists to *c.* -2.0m OD when an organic mud was deposited, with increasing mineral content up the sequence to the detriment of the humified organics. The mineral sediment is sealed by modern fill at -1.15m OD.

### BH6

The top of the gravel terrace is at -2.52m OD, overlain by degraded wood, which is in turn sealed by a humified peat, the base of which was dated to 4750±70 BP (Beta 93683; -2.52 to -2.47m OD, 3660-3360 cal BC). There is a low mineral content within the deposit at this level (-2.49m OD) that increases up the profile. From *c.* -1.9m OD, the organic content is very low and the deposit is almost entirely waterlain silts with occasional woody fragments and traces of degraded organic matter. Several thin lenses of humified organic material are present, at *c.* -1.82m OD and *c.* -1.6m OD. From -1.54m OD, the deposit coarsens, suggesting a higher energy of flow across the sampling site. This does not persist and the deposit fines up and exhibits iron staining from this point, possibly indicating that the site became exposed as the depositional processes changed, with slower accumulation of silts across the site. This deposit persisted until *c.* +1.75m OD where it is truncated by modern fill.

There is a small amount of woody material present within the overall mineral matrix of the last sealed deposit and two radiocarbon dates were obtained to establish a chronology and examine accumulation rates, firstly 3700±50 BP (Beta 93682; 2280-1940 cal BC, -1.12 to -1.09m OD), the Early Bronze Age. The second was 750±60 BP (Beta 93681; AD 1160-1400, +0.76 to +0.79m OD). This last date is important as historic period dates are rare within floodplain deposits in London, mainly owing to the lack of organic sedimentation at this date and the difficulty of dating the minerogenic deposits. A sample for pollen assessment at +0.80 to +0.82m OD showed conifers present and, although unusual, may represent plantations to provide timber for the City of London, which was expanding rapidly at this time. Cereal is also present in large amounts and doubtless reflects local arable cultivation. Wetland species such as *Typha latifolia* and *Osmunda regalis* (royal fern) show that the site was still influenced by local waterbodies at this date, and the presence of Chenopodiaceae, *Atriplex* (orache) and *Salicornia* (glasswort) indicate that some of this water is coming from the tidal Thames.

### BH7

A thin layer of organic mud overlies the gravel terrace at -1.35m OD. The organic mud contains traces of wood. More mineral-rich sediment replaces this from -1.29m OD, with some traces of highly degraded organics and some wood fragments. This base of this mineral deposit dates to 5180±70 BP (Beta 93680; 4230-3790 cal BC, -1.27 to -1.30m OD); the Mesolithic/Neolithic transition. It fines upwards, but no bedding was observed. From -1.15m OD, the organic content increased substantially, leading to peat formation. This deposit was almost a metre in thickness; it may have been thicker but there was a hiatus between U4/100 cores at this point. The top of what was recovered dates to 3160±70 BP (Beta 93679; 1610-1250 cal BC, -0.18-15m OD), i.e. the Middle Bronze Age. Deposition changes from +0.5m OD where clay silts were recovered, interleaved with a thin peat and occasional thin organic muds with iron staining, possibly indicating some periods of sub-aerial weathering. This sequence of clay silt with occasional organic deposits persisted to +2.47m OD where it was sealed below modern overburden.

## BH8

The Shepperton Terrace occurs below -2.63m OD and consists of sand and gravel, mollusc shell and some plant material (figures of up to 8% organic carbon were obtained from these horizons). Two radiocarbon dates were obtained from the plant material in these gravel deposits: 10310±90 BP (Beta 101867; 10840-9740 cal BC, -2.53 to -2.52m OD) and 10010±70 BP (Beta 93678; 9900-9270 cal BC, -2.43 to -2.40m OD). These dates place deposition of the organic material at the Devensian/Holocene transition.

Pollen assessed by Dr. Rob Scaife from -2.45m OD indicates cold climate conditions characteristic of this period. Species include *Dryas octopetala* (mountain avens) and *Plantago maritima* (sea plantain) whilst *Betula* and *Pinus* are the most common tree species, but herbs are the dominant plant group with Poaceae and Cyperaceae to the fore. Fine-grained sediment was present in the upper levels of the terrace at *c.* -2.4m OD. The $\chi^{lf}$ values to this point were relatively low but increase from -2.38m OD with a peak of 36 $m^3$ $kg^{-1}$ (see Appendix 5, Table 74). This is not really high enough to indicate major changes such as might occur through burning or pedogenesis (Dearing et al. 1985), which would need values in the hundreds. The deposit fines upward with the gravel and sand being gradually lost whilst the organic content increases. The percentage organic carbon values correspondingly increase, but do not achieve values higher than 50%. This indicates that deposition is still occurring in a period during which mineral sediment was being washed onto site (see Appendix 5, Table 75). A third radiocarbon date of 9360 ±70 BP (Beta 120958; 8800-8330 cal BC) was obtained from some of this organic material at -2.26-2.20m OD, indicating that accumulation of sediment is taking place fairly gradually with this level dating to the Early Mesolithic. Pollen from this level (-2.25m OD) shows a reverse in dominance with tree species much increased to the detriment of the herbs; *Pinus* is the dominant species with *Betula* and *Quercus* also represented; a typical spectra for the Early Holocene.

From *c.* -1.7m OD a black organic mud is present with only a few discernible pieces of wood. The percentage organic carbon values increase from this depth up to 65% in the middle of the deposit but then drop off. The organic mud persists to -1.5m OD where the organic content decreases relative to silt clay, with a few traces of wood and highly humified organic matter. The percentage of organic carbon present correspondingly drops, reaching to values as low as 12%. The pollen indicates that the deposit is forming in or close to a wooded environment with greatly reduced *Pinus,* greatly increased *Quercus,* and *Tilia, Ulmus* and *Corylus avellana* type appearing. *Alnus* also occurs and may be evidence for the Early Holocene rise in *Alnus* that has been suggested elsewhere, both in the Thames and southern England (Waller 1998; Rackham and Sidell 2000).

The organic component increases once again from *c.* -1.2m OD, in places achieving 80% organic carbon content. These values fluctuate with occasional low readings suggesting periodic inwash of mineral sediment, i.e. at -0.215m OD where 45% TOC was recorded. Some large pieces of wood were present and moss (probably having lived on the trees) along with herbaceous plant fragments. A radiocarbon date was obtained from wood towards the base of the deposit, giving a measurement of 5010±70 BP (Beta 120960; 3960-3660 cal BC, -1.0-0.96m OD). This suggests that deposition was very gradual or that there was a hiatus in the sequence at this date (Early Neolithic), which is significantly later than the Early Mesolithic date 1.2m below in the sequence. The $\chi^{r}$ values drop sharply at the base of this deposit to approximately 5 $m^3$ $kg^{-1}$ which is normal for a change from mineral to more organic deposits. The values stay generally low throughout the peat with occasional higher readings (i.e. at -0.72m OD and -0.215m OD of 26 and 46 $m^3 kg^{-1}$ respectively) that would seem to suggest periodic influxes of mineral sediment. A diatom sample (-0.75m OD) examined (by Dr. Nigel Cameron) during the early stages of the project yielded some of the only valves recovered from the site. The assemblage contained *Cyclotella striata, Rhaphoneis/Delphineis* sp., *Thallasiosira* sp., *Synedra ulna, Navicula mutica* and *Hantzschia amphioxys,* showing a range of fresh, brackish and marine species indicating that the site was in contact with the estuary, but that a freshwater input to the site was maintained perhaps forming at high marsh level (Zong 1999).

The peat ended at *c.* +0.5m OD and this was dated to 3070±60 BP (Beta 120959; 1450-1120 cal BC, +0.38 to +0.42m OD), the mid/later Bronze Age and so appears to have formed over two thousand (radiocarbon) years, with a mean accumulation rate of roughly 10mm/ 12 years. It is overlain by a thick silt clay with some sand at the base of the deposit, but fines upwards. Some traces of organics were observed but these are highly degraded and may have been reworked. However, a date of 2430±50 BP (Beta 93677; 770-400 cal BC, +0.89 to +0.95m OD) from this undifferentiated organic matter suggests this is not the case and that either the organics continued to be washed in or were forming *in situ* at this point in the Iron Age. Organic carbon values are low throughout this deposit, generally below 15%. The $\chi^{lf}$ values increase from the underlying peat but not dramatically, with a maximum value of 43 $m^3 kg^{-1}$ which corresponds with one of the mineral influxes within the peat horizon.

Pollen from +0.95m OD shows the contemporary environment to be dominated by herb pollen, particularly cereal with *Plantago lanceolata,* and *P. media/major* (hoary/great plantain). If the cereal indicates local cultivation at this date, it is extremely important as the human presence during the first millennium cal BC is highly enigmatic in central London (Merriman 2000) and any information on human activity is important. There is a small woodland element, presumably on drier ground further away which includes *Quercus, Ulmus, Betula* and *Pinus. Alnus* is also present but is likely to reflect marshy conditions nearer the sampling site. Chenopodiaceae may indicate that there is a brackish element to this.

A short hiatus between U4/100 cores occurs at *c.* +2.0m OD and the contact from this silt clay to the overlying silty sand (containing some gravel) was lost. Initial scanning of a diatom sample from +2.27m OD containing a few valves only indicated a mixed environment with marine, brackish and freshwater species. These included *Delphinius surirella, Cyclotella striata* and *Fragilaria pinnata,* suggesting that although the site was dominated by the tidal Thames, there was freshwater coming onto site, possibly via a channel to the north. The deposit coarsens upwards to +2.7m OD where there is an abrupt transition to a thin band of highly humified wood peat. This is sealed, again with an abrupt contact by a further sand-dominated deposit. Another thin organic deposit seals the sand, at +2.9m OD, but it is less organic than the previous thin peat lens. It is sealed by a thin silt clay, with some traces of degraded organics. The grain size increases and the top of the sequence consists mainly of sand with some gravel-sized clasts, sealed by modern fill at +3.165m OD.

## 8.3 Site summary

The Shepperton Terrace occurs at variable depths across the site, between -3.4m OD to -1.6m OD; but typically at approximately -2.5m OD. There is no discernible pattern to the varying depths that must be put down to natural undulations in the preserved surface of the gravel. The earliest dates for the sequence come from BH8 where organic matter within the upper gravel has been dated to the Devensian/Holocene transition. No other deposits have dated to this period and it must be concluded that if sediment was deposited elsewhere on site, it was subsequently eroded. It seems likely that the sediments in BH8 were somehow protected from such erosion, possibly within a relict channel, which gradually silted up, burying these early deposits. A channel has previously been identified in this area (see Figure 70) in the existing borehole logs and it is thought that BH8 lies within this channel.

The sediments overlying the gravel across the site consist of sands, organic muds and peat. The sand (BH8) is part of the palaeochannel and an associated date indicates that this is still an Early Holocene deposit and not subject to the erosion indicated elsewhere across the site. Pollen indicates that the prevailing conditions were a cold climate pre-boreal landscape dominated by species such as pine, with an early development of alder. Peat is present in BH2, BH3, BH4, BH5 and BH6 and the lowest contacts give dates of between 5660-4750 radiocarbon years BP. This would suggest that most of the site is consistently developing a woody peat from the later Mesolithic with varying hiatuses between the gravel being deposited and the peat forming. In BH7, an organic mud overlies the gravel and this may be related to its proximity to BH8 where the palaeochannel is thought to be located and could be depositing fine sediment close by. This was sealed by a substantial peat bed, which gave a Late Mesolithic/Early Neolithic inception date consistent with the peat in the other locations. It begins forming earlier in the north of the site at *c.* 5770 radiocarbon years BP whilst it does not start forming until *c.* 5100/4750 radiocarbon years BP to the south.

The peat sequence is variable across the site (although it is consistently humified) and includes periods of inundation and the formation of organic muds in places. The limited biological evidence suggests that it is a wood peat, probably formed within an alder carr. There is also some evidence for the influence of brackish water across the site by this date (Early Neolithic). Furthermore, there is some evidence for nearby arable cultivation. The depth of peat is variable across the site, potentially as a result of differential erosion and compaction (BH4, nearest the Thames is the most affected by flooding, although it is BH3, further to the north, but not the most northerly borehole, that has the thinnest peat). The top of the peat deposit is located at varying altitudes across the site. This may result from a number of factors: differential compaction, erosion or truncation or simply that it persisted longer in some places. It survives to *c.* +0.5m OD in BH8, which is the most northerly location and this provides the latest date (2430±BP), indicating that inundation came slowly from the south, i.e. the Thames. BH4, the most southerly hole gives a date of 3700±BP and an altitude of -0.84m but there is a possibility that there has been some truncation here. However, if these are 'real' dates then it may be possible to track the end of peat formation across the sites north-south axis, with this taking 1300 radiocarbon years to overtop the peat between BH4 and BH8 (just over 300m). This is possibly supported by the date of 2630 radiocarbon years BP for the top of the peat in BH2, also at the northern edge of the site, but to the east. However, the horizon is 2m below that in BH8 and is difficult to convincingly explain unless compaction and some erosion by the subsequent muds may be cited. The extremely scanty diatom evidence indicates that whilst this peat is forming, there is contact with the estuary, which could point to occasional floods but might mean that the peat is forming under conditions of rising sea level.

The peats were sealed by silt clays across the site which in some places are laminated, suggesting that the inundation was a gradual process occurring over some time. The larger clasts within these muds may have come from erosion close to the sampling site rather than a substantial increase in the energy of flow across the site generally. There is evidence indicating that these muds are derived from estuarine waters although there also appears to be a freshwater input. The presence of a medieval peat within these muds in BH3 is rare because most sites in the Thames are sealed purely by mineral sediment with very little organic accumulation after the Iron Age. This, combined with the problem of dating inorganic sediments is one of the key problems associated with resolving the sea level record for the historic period in the Thames and elsewhere. The medieval peat at Silvertown suggests a negative tendency of movement, but as it is only found in the one borehole may represent a very localized event. The pollen evidence from the peat is extremely useful in that it suggests not only local arable cultivation, which is to be expected at this date, but the presence of softwoods potentially indicative of managed woodlands, which would have been important owing to the demand for building timber.

The sequence here, although locally complex, represents a reasonably simple pattern overall (see Figure 78). An Early Neolithic wood peat overlies the Shepperton Terrace in all locations except where a palaeochannel is preserved. The peat is of longest duration in the north, forming earlier (Late Mesolithic) and persisting longer (Bronze/Iron Age transition) than the peats closer to the Thames. These do not form until roughly 700 radiocarbon years later and are inundated up to 1300 radiocarbon years earlier than those at the north of the site. The peat seems to be formed mainly within an alder carr, but there is also evidence for contact with the estuary. The peats are sealed by estuarine mud with an important organic horizon dating to the medieval period.

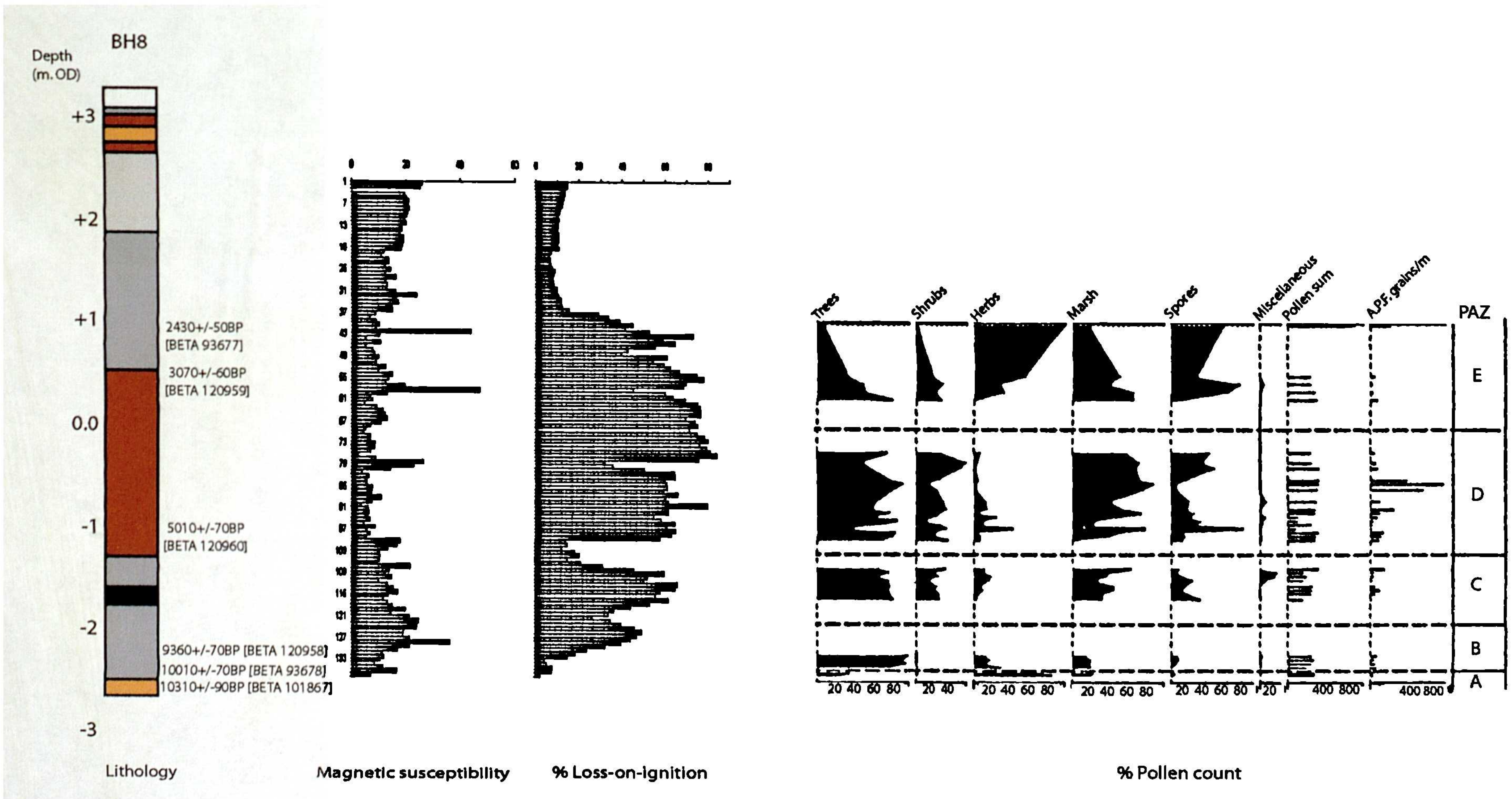



Figure 78. Silvertown Urban Village summary diagram

# *Chapter 9. Masthouse Terrace, Isle of Dogs, London Borough of Tower Hamlets, E14 (TQ 3750 7850)*

## 9.1 Introduction

### Site Location

Masthouse Terrace (code MHT95, GLSMR 083421, 1 on Figure 79) is located on West Ferry road at the southwestern corner of the Isle of Dogs (2 on Figure 79) in the London Borough of Tower Hamlets. The site fronts onto the modern Thames and was formerly a boatyard with a slipway. West Ferry road is the main road following the edge of the Isle of Dogs, and is likely to be an historic route built behind the early river walls leading through to ferries running to the other side of the Thames. The Isle of Dogs is a prominent peninsula around which the River Thames, to the south, flows, opposite the Greenwich peninsula (3 on Figure 79). The modern setting is urban land and riverscape, juxtaposing run-down docks and riverside industry with extensive luxury apartment and office construction. The northern end of the Isle of Dog is considered part of London's East End, whilst the southern end is now considered part of London 'Docklands' (4 on Figure 79).

The Roque map of 1747 shows the site to be unoccupied, and the area is thought to have been salt marsh at the time. The industrial aspect commences relatively late with evidence that the site was undeveloped in 1835 (Hawkins 1995). It then became a shipyard (Napier Yard) where ships such as the *Great Eastern*, designed by Isambard Kingdom Brunel were built and launched down a substantial slipway into the Thames.

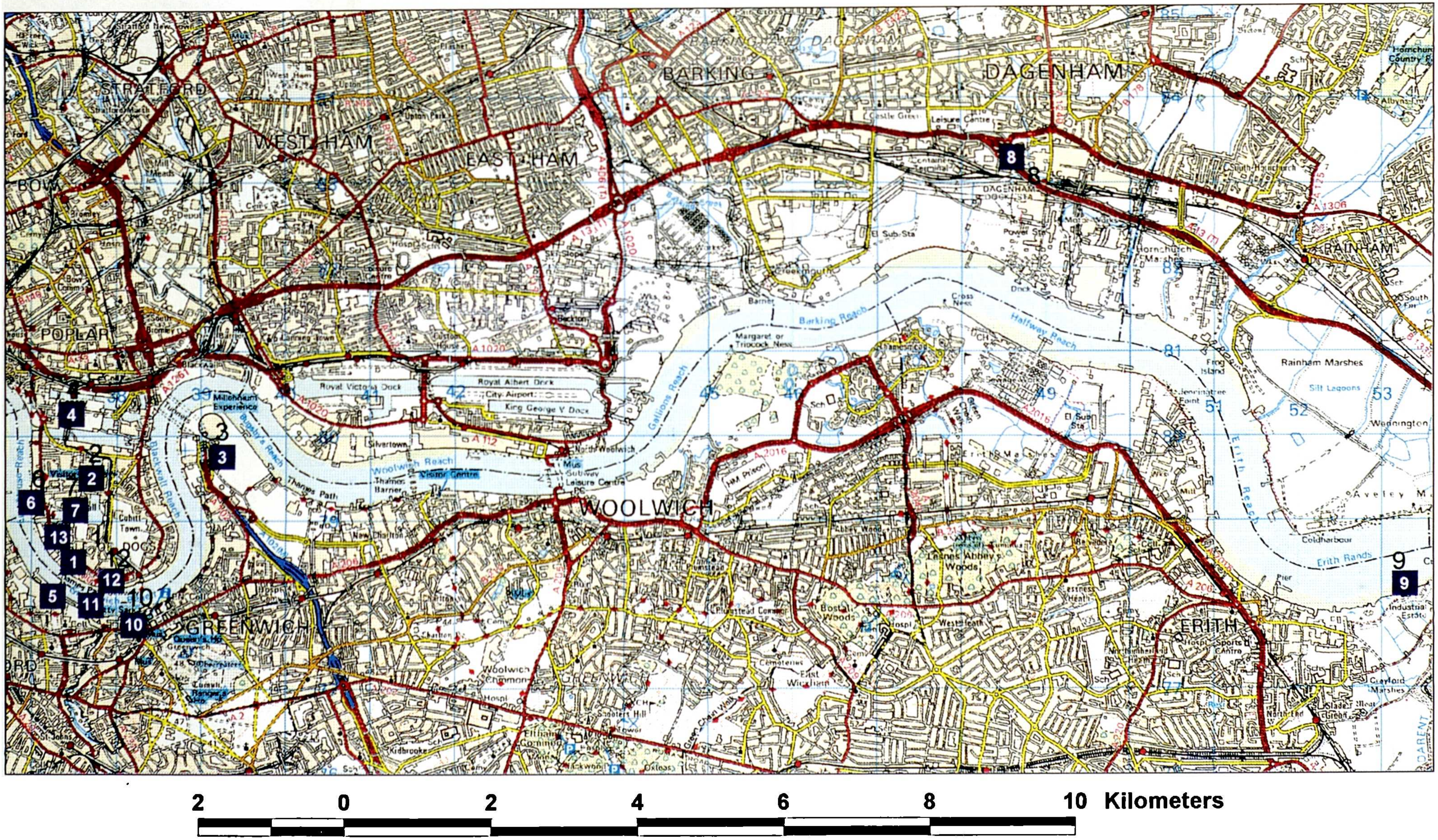



Figure 79. Location map of Masthouse Terrace and other sites mentioned in this chapter

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Masthouse Terrace | 3750 | 7850 |
| 2 | Isle of Dogs | 3775 | 7950 |
| 3 | Greenwich peninsula | 3925 | 7975 |
| 4 | Docklands | 3750 | 8025 |
| 5 | Fergusons Wharf | 3725 | 7810 |
| 6 | Atlas Wharf | 3701 | 7920 |
| 7 | Millwall Dock | 3750 | 7910 |
| 8 | Dagenham | 4860 | 8330 |
| 9 | Erith | 5330 | 7820 |
| 10 | Greenwich | 3820 | 7780 |
| 11 | Deptford | 3770 | 7800 |
| 12 | Lockes Wharf | 3793 | 7827 |
| 13 | Winkleys Wharf | 3730 | 7880 |

Table 22. Sites shown on Figure 79

## Previous Research

The stratigraphy of the Isle of Dogs has not been considered in any great detail previously and there appears to be no examination of sea-level change associated with the area. The site is significantly upstream (over 10km) of Devoys sampling corridor (1979). The stratigraphy of isolated sites nearby has been examined, but the area has been surprisingly neglected and no synthesis of these data exists within archaeological or geographical publications. Geotechnical examination of the overall site undertaken by the London Docklands Development Corporation prior to archaeological investigation showed a complex sequence of several distinct peats interdigitating with clay silt in the centre of the site, whilst the peat is absent elsewhere. Excavations at Fergusons Wharf (GLSMR 083761, 5 on Figure 74), next door to Masthouse Terrace showed a similar sequence of gravel, silt clay and a substantial peat horizon (Bishop and Brown 1996). Another site, Atlas Wharf (GLSMR 084645, 6 on Figure 79), on the river frontage just to the north of Masthouse Terrace has recently been examined and consisted of gravel (Shepperton Terrace) at depth, sealed by silt clay, a substantial peat horizon dating from before *c.*4000 cal BC, approximately 2m thick, and a final massive silt clay below the modern truncation (Lakin 1999, and see Figure 79). A 'prehistoric forest' was identified by an antiquarian (Cowper 1853, 23) in the mid nineteenth century immediately to the south of the Millwall Lower dock (GLSMR 080889, 7 on Figure 79) just to the northeast of Masthouse Terrace. Sadly this is not described in any detail, except to note the presence of hazelnuts.

It seems likely that this was a peat bed with preserved tree stumps, as have been found in other areas of the Thames floodplain such as Dagenham (Spurrell 1885, 8 on Figure 79) and Erith (Seel 2000, 9 on Figure 79).

The site is not within an archaeological priority zone and this area is not particularly well known for anything other than its industrial heritage. Nevertheless, there is some information, the oldest being Mesolithic (see Wymer and Bonsall 1977) and Neolithic axes (Adkins and Jackson 1978) which have come out of the river. Naturally, provenance is difficult and the axes may have gone into the river elsewhere, but it is a relatively large amount within 1km of the sampling site. There is no occupation until the Bronze Age, which has been identified at Atlas Wharf where a number of timber platforms were discovered adjacent to a stream running to the Thames (Lakin 1999). The area seems to have been abandoned until the medieval period when several manor houses and hamlets grew up at the southern end of the Isle of Dogs (GLSMR 084275). There is also archaeological evidence close to Masthouse Terrace for a medieval ferry to Greenwich (GLSMR 080979, 10 on Figure 79) and Deptford (GLSMR 080980, 11 on Figure 79). River defences were put in at this date, with traces of the medieval river wall at Lockes Wharf, (GLSMR 084316, 12 on Figure 79), a few hundred metres to the south east of Masthouse Terrace. As well as defences, a late medieval eel trap at Fergusons Wharf (GLSMR 083762) is evidence for exploitation of the rivers resources. Evidence exists for further river defence construction in the post-medieval period, particularly at Atlas Wharf (Lakin 1999) and also more exploitation of the river, with the construction of postmedieval windmills along the river wall (hence the local placename, Millwall) at Winkleys Wharf (Wooldridge 2000, GLSMR 084928, 13 on Figure 79). As mentioned above, industrialization came fairly late, but from the mid-nineteenth century, the area was turned over to iron working, chemical manufacture and shipbuilding.

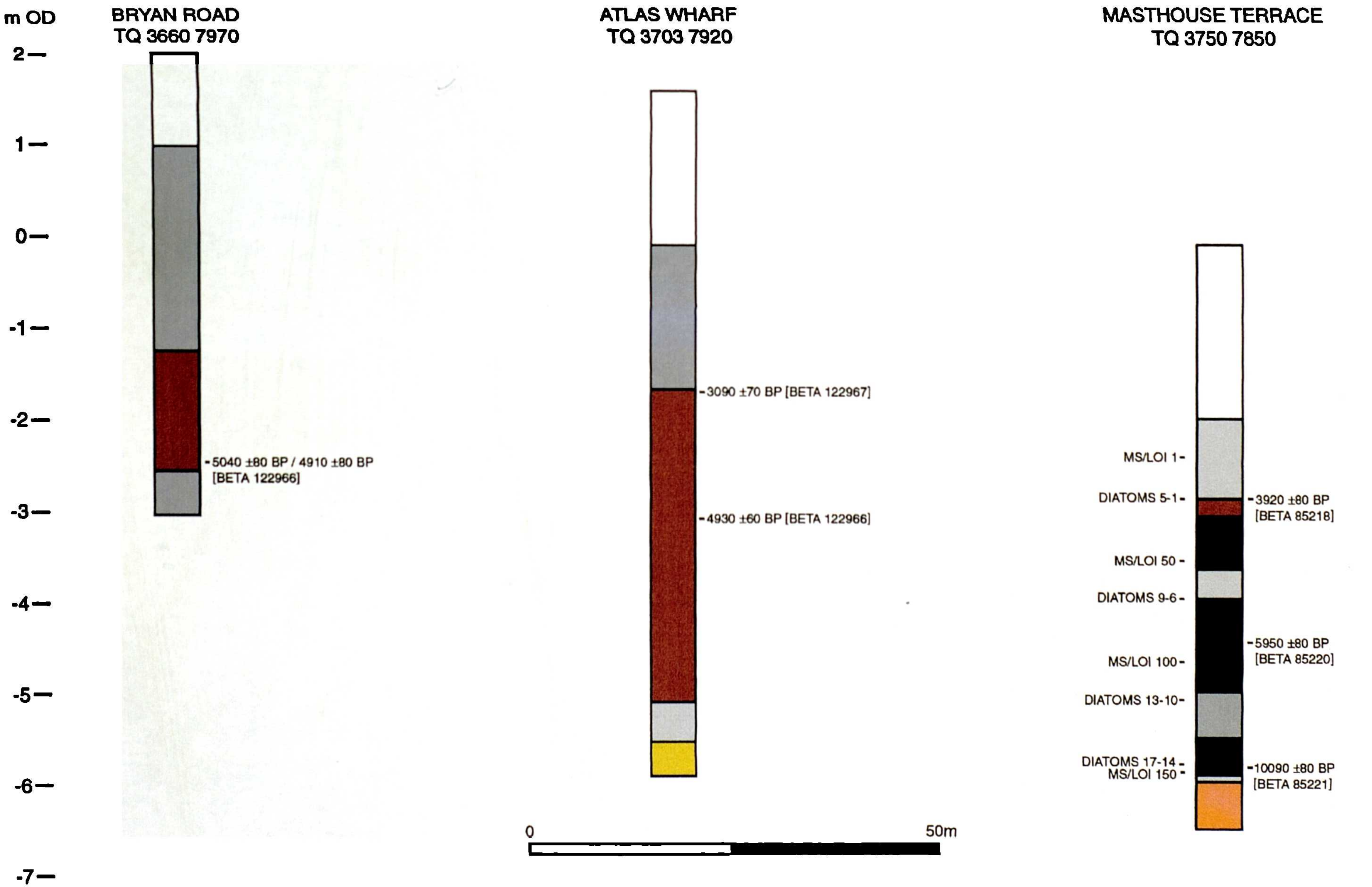



Figure 80. Stratigraphy in the vicinty of Masthouse Terrace. See Figure 91 for key.

## The Project

An archaeological evaluation was carried out on site in 1995, and as part of this three boreholes were drilled (see Figure 81) using a shell and auger cable-percussion rig. U4/100 samples were collected for analysis from all undisturbed sediment to characterize the sequence and then examine the possibility of archaeological survival within the sediments encountered. This was done in order to inform the planning process. Several trenches were then opened to examine the site for archaeological material, and part of the earlier slipway was recovered, but nothing else. Owing to health and safety constraints, the trenches could not penetrate to more than a depth of 3.6m below ground surface and so did not penetrate far beneath the modern overburden, or indeed below OD.

Gravel of the Shepperton Terrace was penetrated in all boreholes although it was only possible to collect it in one owing to the poor retention of loosely consolidated sediment. Twenty-four samples were collected and a preliminary assessment of the samples was undertaken. These showed a complex sequence, with variation in the stratigraphy between the various boreholes. Radiocarbon assay was subsequently undertaken, and the results produced a rare Early Holocene date and several mid-Holocene dates. No examination was made of microfossils at this stage. As a result of this initial assessment, the site was selected for detailed analysis for the following reasons:

- *The relatively complex sedimentary sequence which suggests unusual local processes*
- *The rare long sequence with the Early Holocene date*
- *The possibility of examining mid-Holocene relative sea-level changes*
- *The position relative to other sites in the project, i.e. extending upstream into inner estuary from the majority of sites*

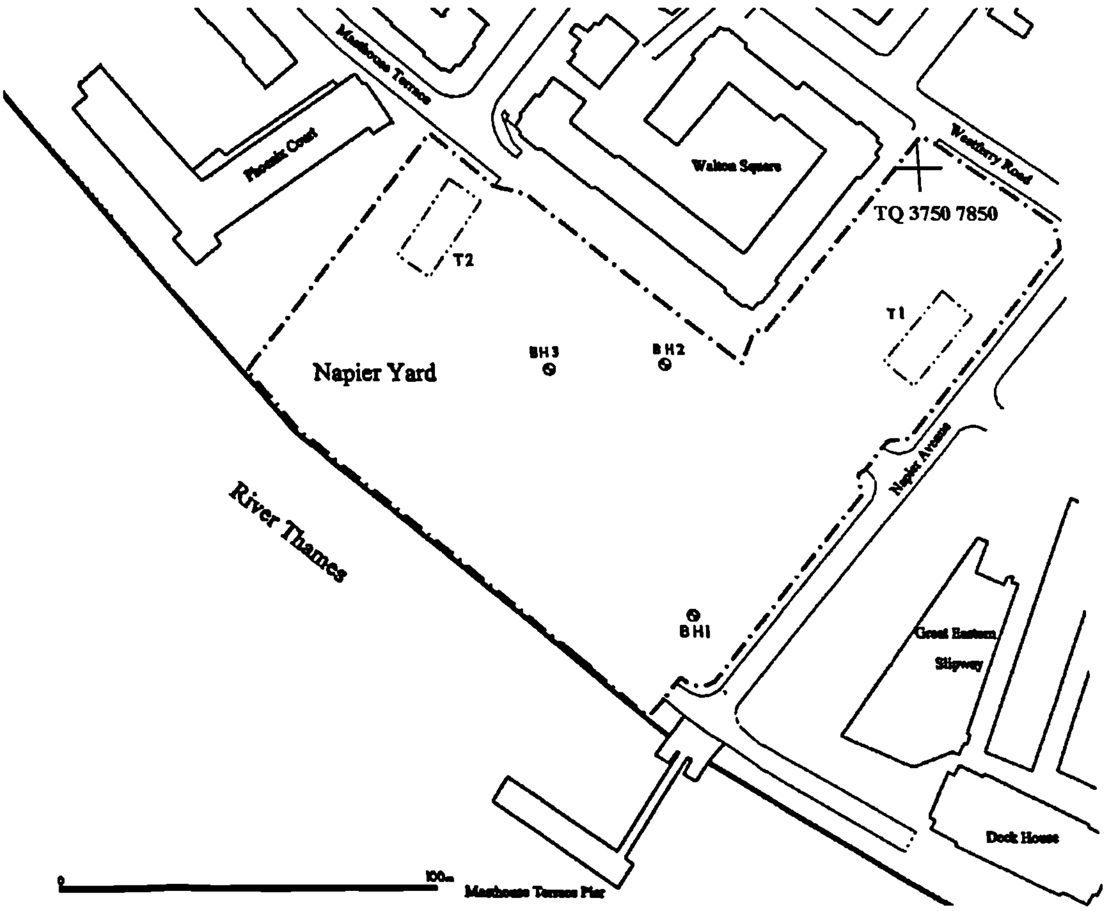



Figure 81. Masthouse Terrace site outline and borehole location plan

## 9.2 The Sequence

The broad pattern at Masthouse Terrace is of silt clays interdigitating with organic muds with some peat formation. Several large deposits of sand testify to the presence of local channel systems (see Figure 82). The full details may be found in Appendix 6.

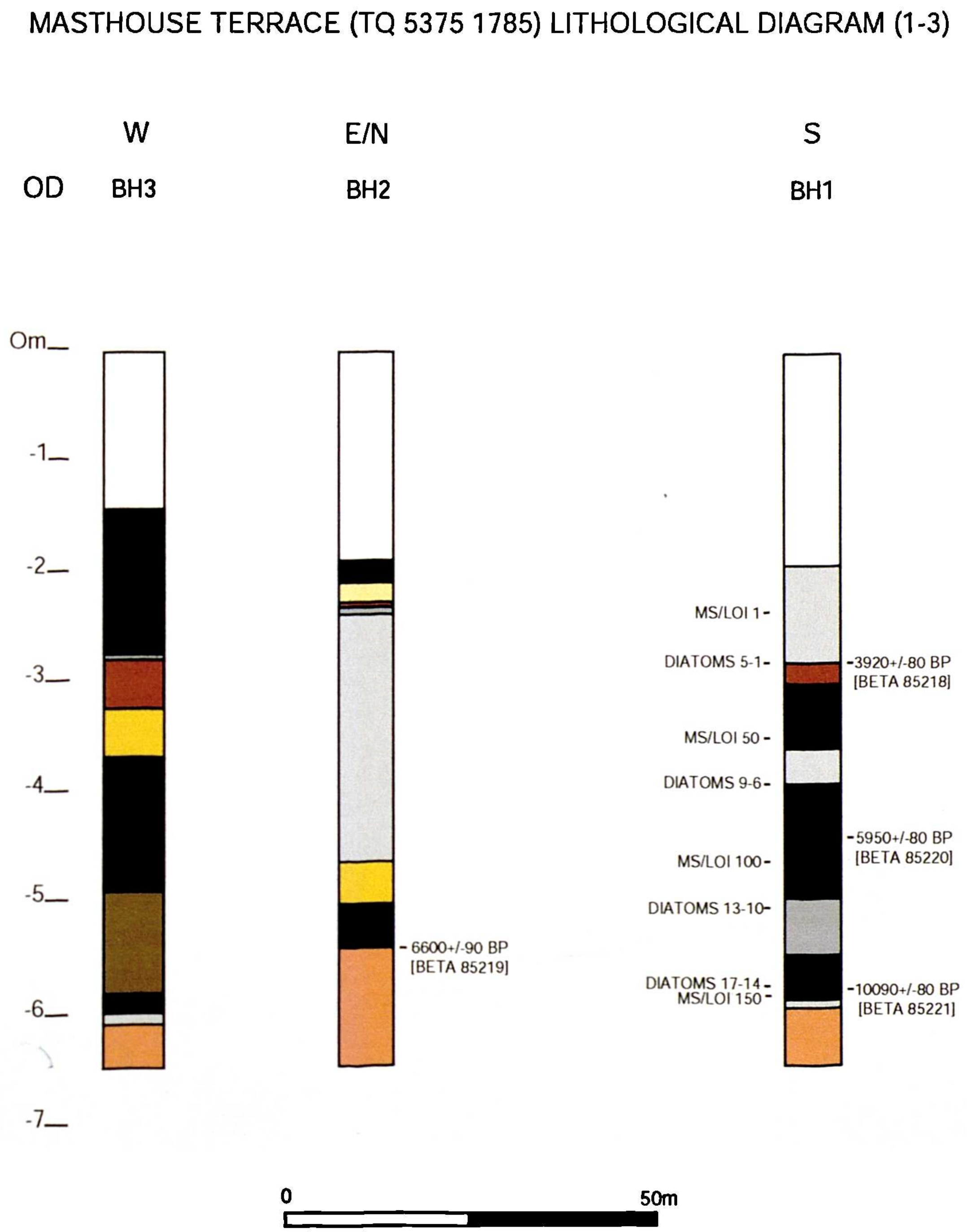



Figure 82. Masthouse Terrace lithological diagram. See Figure 91 for key

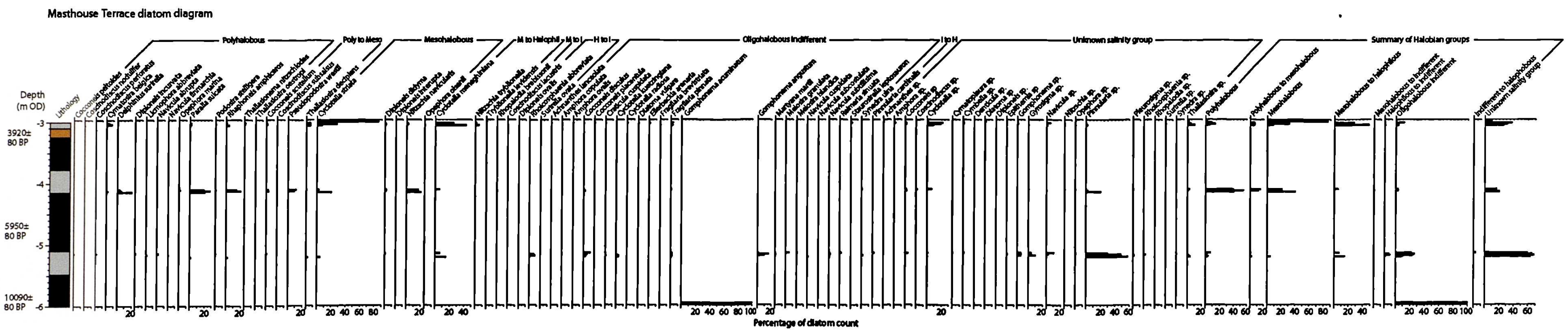



Figure 83. Masthouse Terrace diatom diagram

## BH1

The Shepperton Terrace occurs below *c.* -6.0m OD and is sealed by a silt clay with some sand containing a low proportion of undifferentiated organic material. The contact between this silt clay and the overlying deposit was rather sharp and possibly erosional. The proportion of organic material increases to *c.* 50% in the overlying deposit with a concurrent decrease in $\chi^{lf}$ values (which are all below 10 8m$^3$ kg$^{-1}$) (see Appendix 6, Tables 80 and 81). The base of this organic mud yielded a radiocarbon age of 10090±80 BP (Beta 85221; 10330-9310 cal BC, -5.88-5.83m OD) (see Appendix 6, Table 82). The deposit is degraded but contains fragments of herbaceous plant parts and wood, persisting to -5.5m OD with fluctuations in the relative proportions of organic matter and mineral sediment. Diatom samples collected from the base of this organic mud contained only one valve; *Gomphonema acuminatum* classified by Hustedt (1953) as an oligohalobous indifferent species (see Figure 83 and Appendix 6, Table 84).

Towards the upper levels of the organic mud the organic content decreases and is replaced by a mainly mineral deposit from -5.5m OD; a fine-grained silt clay with a low sand and organic content (20%) and a substantial increase in $\chi^{lf}$ values reflecting this inwash of mineral sediment. The values are not significantly high and do not indicate unusual processes, but define the contrast between mineral and the organic sediment. The deposit persists to *c.* -5.0m OD. Diatom samples from the upper levels around -5.0m, and covering the transition to the next deposit, indicate that the silt clay formed under a combination of initially freshwater and subsequently marine conditions. The lowest diatom assemblage is dominated by *Pinnularia* sp., which forms over 50% of the total valve count (sample 13). Otherwise, only *Cyclotella meneghiniana* reaches figures greater than 5%. Other taxa include *Cyclotella striata, Thallasiosira* sp., *Cocconeis disculus, Paralia sulcata, Rhaphoneis amphiceros* and *Rhoicosphenia abbreviata.* Although the *Pinnularia* sp. valves were not identified to species, it is assumed that they represent the kind of depositional environment suggested by the *Pinnularia major* group of Vos and de Wolf (1993) who classify the sedimentary environment represented by *P. gibba, P. major* and *P. nobilis* and others as intertidal to lower supratidal mudflats, creeks and lagoons. *Rhoicosphenia abbreviata* and *Cocconeis disculus* are freshwater species (Barber and Haworth 1981; Denys 1992); the other species indicate brackish-marine conditions:

*Cyclotella striata* and *Rhaphoneis amphiceros* are both good examples of species found in large tidal channels. *Paralia sulcata* may also represent this type of environment, but could be associated with salt marsh conditions (Zong 1999).

The subsequent samples show a change to the conditions reflected in sample 13 at -5.08m OD. The dominance by *Pinnularia* sp. declines whilst the other freshwater species *Rhoicosphenia abbreviata* and *Cocconeis disculus* increase in abundance. The more obvious estuarine and marine species such as *Cyclotella striata* and *Paralia sulcata* are not present in large proportions, but above -5.02m OD a more estuarine trend is apparent with species such as *Cocconeis scutellum, Cocconeis peltoides* and *Pseudopodosira stelligera* all appearing for the first time, although *C. scutellum* has previously been recorded in high/middle marsh (Zong and Horton 1999).

Above -5.0m OD, the sediment is more organic-rich with a series of black organic muds, initially achieving up to 95% organic content, but generally fairly consistent at around 40% TOC. The sediment is poorly preserved with few identifiable fragments, with the exception of some woody pieces towards the top of this deposit (-3.94m OD), including one fragment that filled the core. Much of this organic mud exhibits iron staining, suggesting fluctuating water tables and a tendency for the peaty sediment to have periodically dried out. The $\chi^{lf}$ values decrease from those exhibited in the lower mineral sediment and drop to -2 $8m^3 kg^{-1}$ at -4.07m OD, corresponding with the peak of organic content. There is some fluctuation of the $\chi^{lf}$ values within this organic band, but the broad trend is of low susceptibility compatible with organic deposition and occasional inwash of mineral sediment. No significant increases are apparent, which indicates that at no point did the deposit dry out sufficiently for the formation of a palaeosol. The contact to the subsequent deposit was sharp and may indicate some erosion of the upper organic mud surface. The organic content drops to approximately 10% at this point. The middle of this organic mud (-4.39 -4.31m OD) dates to 5950±80 BP (Beta 85220; 5040-4620 cal BC), the Late Mesolithic.

Diatom samples were examined from the top of this organic mud and consisted of variably preserved assemblages. The lowest sample (9, -4.02m OD) contains only a few valves (*Cyclotella striata, Nitzschia navicularis, Paralia sulcata, Delphineis surirella* and *Pinnularia* sp.); a group that indicates a combination of exposed mudflat and tidal channel sedimentation probably within the intertidal zone. However, the counts are too low to be meaningfully interpreted. The estuarine species *Paralia sulcata, Rhaphoneis amphiceros, Nitzschia navicularis* and *Pseudostelligera westii* dominate samples 8 and 7 (-4.0 and -3.98m OD). Only a few valves of *Pinnularia* sp. were present. The assemblage is strongly estuarine and continues to suggest an intertidal environment, possibly with mud flats, evocative of a combination of Vos and de Wolfs (1993) *Melosira (Paralia) sulcata, Navicula digitoradiata* and *Rhaphoneis amphiceros* groups. The contact with the overlying deposit contained no diatom valves.

Above -3.94m OD, a relatively narrow band of dark grey silt-clay with some sand and degraded organic matter occurs, which coarsens upwards. $\chi^{lf}$ values are much higher than in the organic mud below and confirm the presence of more mineral dominated sedimentation. The contact between this and the next deposit was unfortunately lost between two U4/100 cores at this point, so the nature of the contact is not known. From -3.6m OD, the organic content increases but still contains minerogenic sediment. The organic component is badly preserved, dominated by unidentifiable material but with a higher wood content than previously encountered. The percentage of organic carbon reaches 70%, but is more commonly around 50% with correspondingly low $\chi^{lf}$ values. Small lenses of silty sands are present within the main group, perhaps indicating periodic flood events. Once again, the contact between sedimentary deposits is lost between U4/100 cores, and the sequence recommences at -2.99m OD, with a thin deposit of humified organic mud. This consists almost entirely of unidentifiable organic matter, with minerogenic sediment and detrital woody fragments. There is a gradual change, with the organic content decreasing to an almost entirely mineral sediment with occasional traces of degraded organic matter. $\chi^{lf}$ values double, but again are still relatively low and show nothing more than a change from organic to mineral dominated sedimentation.

Diatoms were analyzed between -2.86 and -2.76m OD to examine the conditions at what appears to be a clear positive tendency of sea-level movement. No valves were recovered from the lowest sample (5, -2.86m OD), however, the remaining samples demonstrated good preservation. The assemblages are significantly different from the previous samples at *c.* - 4.0m OD. *Cyclotella striata* and *Cyclotella meneghiniana* dominate the assemblages, whilst other estuarine taxa such as *Paralia sulcata, Nitzschia navicularis, Rhaphoneis amphiceros* and *Delphineis surirella* were recovered in quantities below 5% of the total valve count. The assemblage strongly suggests deposition within/adjacent to a tidal channel environment, as do species such as *Cymatosira belgica* and *Thallasiosira decipiens,* neither of which formed a significant part of the assemblages before this point.

Sampling stopped at -2.00m OD which was the contact with overlying modern fill. A radiocarbon sample from the point where the organic input decreased (-2.79 - 2.74m OD), gave an age of 3920±80 BP (Beta 85218; 2620-2140 cal BC).

## BH2

The Shepperton Terrace is present below *c.* -5.6m OD and is sealed by poorly sorted olive brown sand and gravel with a low proportion of silt clay. Traces of degraded organic matter occur, as do small detrital wood fragments. The base of the organic material dates to 6600±90 BP (Beta 85219; 5700-5370 cal BC, (-5.54 - 5.49m OD). The organic content increases slightly, but the overall trend is of a fining upwards tendency with the sediment becoming dominated by clay, with small quantities of unidentifiable organic matter in conjunction with some wood fragments. This persists to -5.04m OD, where there is a change to almost pure sand. The contact from the deposit below is fairly gradual and does not appear to be erosive, but this suggests a significant shift in sedimentary process with deposition deriving from a fluvial/tidal channel. Above -4.63m OD, the sediment begins to fine upwards, with a steady increase in the silt clay content. Furthermore, traces of organic material are present within the matrix. This could represent redeposition of material eroded from elsewhere, but may also indicate that the site is at least periodically exposed, allowing the development of *in-situ* vegetation. Several fragments of wood fill the core within the general clay-silt-sand matrix, which persists to - 2.45m OD, where the organic content increases briefly. The contact between these deposits was lost between U4/100 samples, however, the organic content decreases again for a few centimetres with a fairly sharp contact to a thin organic horizon, almost entirely composed of unidentifiable organic material with some traces of rooty herbaceous material. This organic deposit is sealed at -2.3m OD by a thin sandy silt with a low quantity of degraded organic matter, which fines upwards, and is replaced by a dark brown organic mud with fragments of wood, sealed under the modern overburden at -1.95m OD.

### BH3

The Shepperton Terrace is present below -6.16m OD, and sealed by a deposit of clay silt sand. Some traces of organic material are present, with iron staining, suggesting that the deposit was subject to sub-aerial weathering and may have been a terrestrial surface at times. Above -6.04m OD, the organic component increases, leading to the formation of an organic mud, although the principal component is still mineral sediment. There is a fining up tendency from the previous deposit. No iron staining was observed within the organic mud. The development of the organic component continues with increasingly large proportions of degraded organic matter and decreasing amounts of silt clay. Woody fragments are present throughout. The deposit develops into a major peat bed, consisting of humified unidentifiable organic matter with woody fragments, with small quantities of silt clay present throughout. Two thin minerogenic bands are present within the deposit, presumably representing short-lived inundations of the sample site. The mineral component increases towards the top of the peat (-4.93m OD). There is a fairly sharp contact between deposits at this point, which may suggest a period of erosion. The deposit sealing the peat is an organic mud, with the organic component almost entirely unidentifiable matter with a few wood fragments, persisting to -3.7m OD. The upper levels within the deposit exhibit iron staining, suggesting that the site has been subject to drying, which possibly accelerated the degradation of the organic component. Nevertheless, from this point for *c.* 0.5m, the deposit coarsens up, with sand the dominant grain size and a corresponding reduction in the amount of organic material present. This deposit is sealed by a further organic sediment at *c.* -3.2m OD, again highly degraded, but with wood and herbaceous material, suggesting that the sampling site is once again in a (semi) terrestrial situation, in or above the inter-tidal zone. This persists to -2.88m OD where a thin (80mm) fine grained mineral deposit occurs, sealed by 1.29m of organic mud, with fluctuating but generally low quantities of silt clay. Again, the deposit is highly degraded, but contains small amounts of wood and herbaceous fragments. The organic component increases to -1.5m OD when it was truncated by modern fill.

## 9.3 Site summary

The lowest radiocarbon date from the site (sample BH1/3, see Figure 84) demonstrates organic sediment accretion at the Devensian/Holocene transition above the Shepperton Terrace gravel. The deposit is a fine-grained organic mud that does not appear to be a palaeosol. The base of the lowest organic deposit in BH3 gives a much younger date and so it must be assumed that although they are forming at roughly similar depths, these deposits formed under different conditions. It seems possible, given what is known of the Devensian/Holocene river from elsewhere (Wilkinson et al. 2000 and Chapter 8) that the lower organic mud in BH1 formed in an abandoned channel of the early braided system. BH1 is furthest to the south and may have fallen within the spatial extent of the Thames channels at that date, whilst BH2 and BH3 are located outside the channel system and sedimentation either does not occur in these two locations, or is subsequently eroded.

It seems inevitable that there was either a hiatus in accretion after this initial Holocene sedimentation, or erosion prior to 6600 BP, which is the date for the lowest organic material in BH2 (the most northerly location) at -5.5m OD. This is only 0.1m above the terrace gravel in this location, and 0.3m above the 10090±80 BP date in BH1. Deposition in both cases appears to have taken place in waterlogged environments, apparently with some riverine incursion over the site. The subsequent series of organic deposits present in all three boreholes, albeit as varying types of organic mud, appear to have formed in an environment associated with an estuarine system but with some freshwater input. The diatom evidence for estuarine waters comes from the lower deposits (-5.0m OD) in BH1 and is not radiocarbon dated at this altitude. The radiocarbon date on the base of the organic sediment in BH2 is 6600 BP, but comes from -5.5m OD. The sediments in BH1 are next dated at -4.4m OD to 5950 BP. It seems likely that the organic muds formed between these two dates. Whether the organic sedimentation in BH2 at -5.5m OD was occurring in a similar depositional environment type is less certain. If so, this would push the migration of the tidal head upstream of this point back beyond 6600 BP or 5700-5300 cal BC (Late Mesolithic).

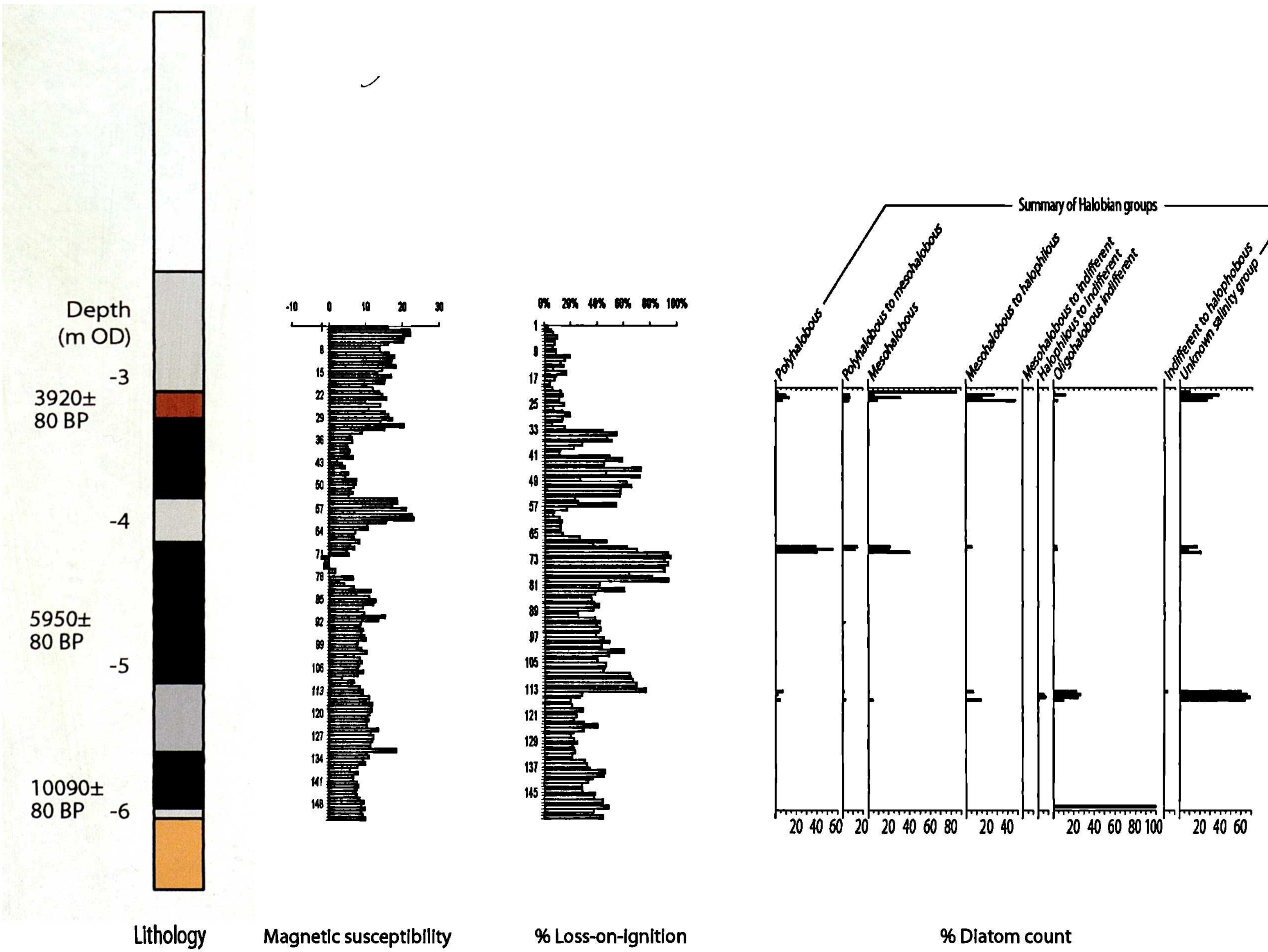



Figure 84. Masthouse Terrace summary diagram

The bulk of the three sequences is taken up by the accumulation of organic muds. However, the sequences are really only consistent at the base, above the Shepperton Terrace. Closest to the modern river, in BH1, the organic mud continues to develop until c. -4.0m OD, suggesting continued accumulation in a wet marshy environment. At these altitudes, the organic deposits in BH3 are much more organic rich, suggesting the river is playing less of a part in sedimentation at this location further north. However, slightly further to the north, in BH2, organic mud persists at these altitudes. This indicates that sedimentation is rather more complex than simply more mineral sediment closer to the river, and more organic further away. This is further complicated by the presence of a substantial sand horizon in BH2, which would appear to derive from in-channel, or channel-side sedimentation. It seems likely that this was the case at the other locations, but sand is not recorded at this depth elsewhere. The deposits in BH2 fine up from -4.5m OD, suggesting the channel migrated away from the sampling site, but there is no development of organic mud until -2.5m OD. This would suggest that BH2 is within the intertidal zone during this period of accretion. There are also phases within the BH1 and BH3 sequences, indicating increased energy of flow, but not on the same scale as in BH2. These two sequences are fairly consistent in deposition of organic material.

The final part of all three sequences indicates that BH2 and BH3 are above MHW with the formation of organic muds, from c. -2.9 (BH3) and c. -2.5 (BH2). The sequence from BH1, however, suggests that at c. -2.8 in 3920 BP, this location becomes more permanently inundated. Unfortunately, the modern fill truncating the site eradicated the point when the site would have become more fully submerged.

The sequence at Masthouse Terrace is complex; over a relatively small area, preservation occurred in several different depositional environments. In broad terms, the sampled sequence starts the deposition and preservation of Late Devensian/Early Holocene sediment, probably within a relict channel. There is a hiatus until the mid Holocene, when organic muds start forming across the site, possibly consequent upon rising watertables associated with sea level rise. The diatom evidence points to Early Holocene freshwater dominance, but with the site in contact with the estuary by this Late Mesolithic. There is some evidence for expansion of the wetland with peat development, but this is not consistent across the site, suggesting it is not a major event within the sequence at Masthouse Terrace. Potentially the site was at the wetland/river margin, which may have migrated laterally over time leading to the complex patterns between the borehole sequences. There is certainly no conclusive evidence for river levels dropping relative to the land, therefore the overall sequence could be taken as an example of a consistent positive tendency of sea level movement from Mesolithic onwards.

# Chapter 10. Suffolk House, 154-56 Upper Thames Street, City of London, EC4 (TQ 3271 8077)

## 10.1 Introduction

### Site Location

The site (code SUF94, GLSMR 044445) is located at 154-156 Upper Thames Street in the City of London at the intersection with Laurence Pountney Hill and Laurence Pountney Lane. It is centrally placed on the southern margins of the City (1 on Figure 85), close to the west side of the northern approach to modern London Bridge and more particularly, Cannon Street Station. The site falls within the area of the scheduled ancient monument designated as the Cannon Street Station Roman Palace. It is situated slightly to the north of the modern route of the Thames within the confines of the estuary.

### Previous Research

Very little detailed analysis has been undertaken looking at the sedimentary history of the area. Test pits within the area of the scheduled ancient monument and the 1969 excavations (see Marsden 1975; Brigham and Woodger 2001) show that the site sits on steeply shelving Pleistocene sand and gravel from which brickearth has been stripped. The steepness of the gravel slope indicates that the site is located at a break of slope, presumably between the Kempton Park and Shepperton terraces. Although there has been some difficulty in distinguishing the clean terrace gravel from outcropping foreshore gravel, it has been indicated that the foreshore was exposed in parts of the site (Woodger 1996). Peninsular House (GLSMR 043494, 2 on Figure 85) sited further east along Upper Thames Street yielded rare Mesolithic peat deposits (Scaife 1983) overlying Pleistocene sand and gravel. Peat has not been found anywhere else in the vicinity.

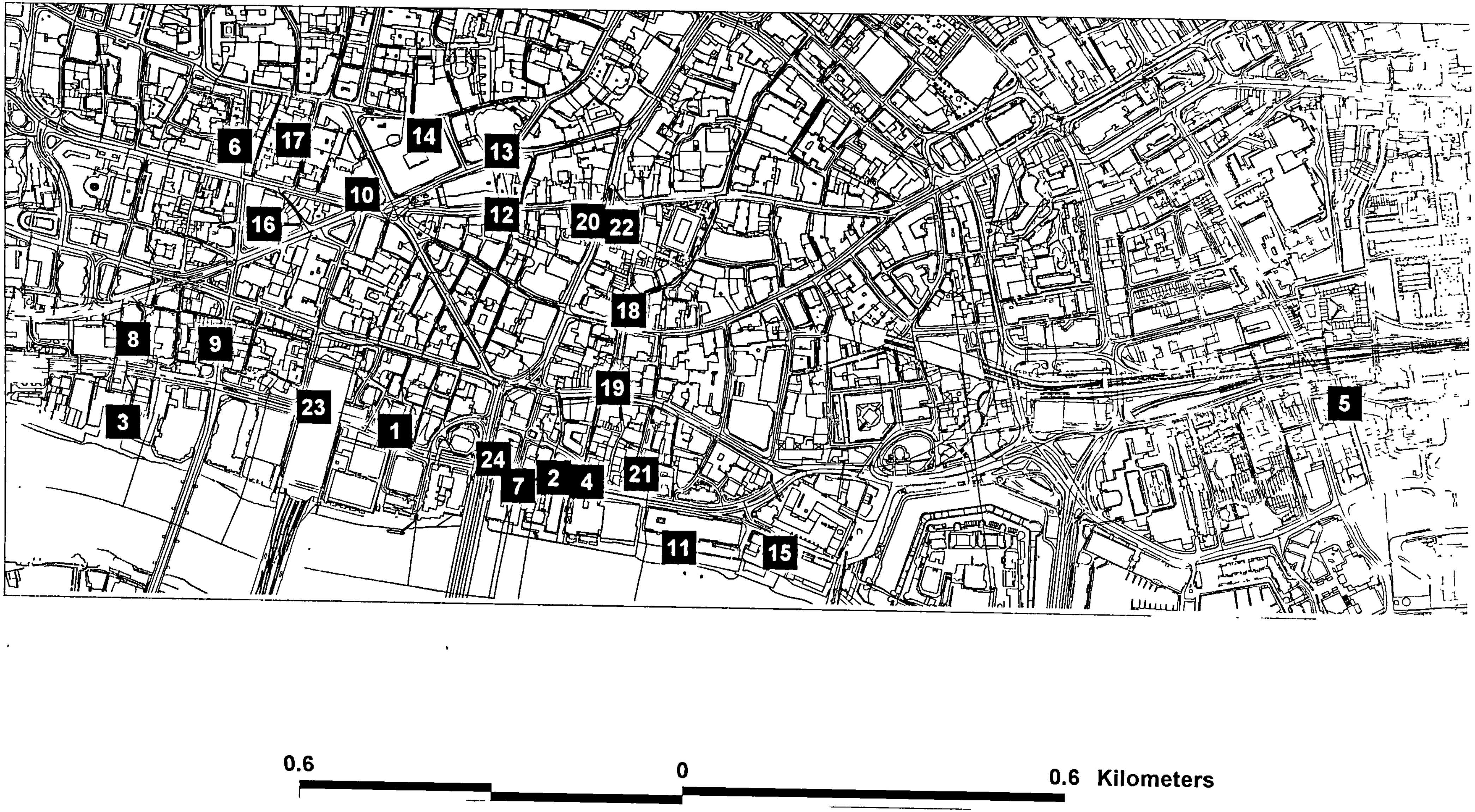



Figure 85. Location map of Suffolk House and other sites mentioned in this chapter

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Suffolk House | 3271 | 8077 |
| 2 | Peninsular House | 3297 | 8070 |
| 3 | Queenhithe | 3229 | 8077 |
| 4 | Trig Lane | 3301 | 8069 |
| 5 | Upper Thames Street | 3420 | 8083 |
| 6 | King Street | 3246 | 8120 |
| 7 | King William Street | 3290 | 8070 |
| 8 | Little Trinity Hill | 3230 | 8090 |
| 9 | Queen Street | 3243 | 8089 |
| 10 | Princes Street | 3266 | 8113 |
| 11 | Lower Thames Street | 3316 | 8059 |
| 12 | Cornhill | 3289 | 8111 |
| 13 | Threadneedle Street | 3289 | 8120 |
| 14 | Bank | 3275 | 8123 |
| 15 | Custom House | 3332 | 8058 |
| 16 | St Benets | 3250 | 8110 |
| 17 | Old Jewry | 3255 | 8121 |
| 18 | Lime Street | 3309 | 8096 |
| 19 | Eastcheap | 3305 | 8084 |
| 20 | Leadenhall Street | 3304 | 8110 |
| 21 | St. Mary-at-Hill | 3310 | 8070 |
| 22 | Gracechurch Street | 3303 | 8110 |
| 23 | Cannon Street | 3260 | 8080 |
| 24 | Regis House | 3288 | 8072 |

Table 23. Sites shown on Figure 85

The sites at Queenhithe (Vintry, Bull Wharf and Thames Court) (GLSMR 042748, Barham and Bates 1991; Ayre et al. 1996; Wilkinson 1998; Wilkinson forthcoming, 3 on Figure 85) are really the only sites along the river frontage in the City where the sedimentology has been researched in any detail. Initially, the work of Barham at Vintry identified a simple sequence of Roman and Saxon upper and lower beds of silt, divided by coarser sands and gravel, identified as primarily waterlain in a rapidly changing environment, with notable impact by human agency with a series of revetments. The subsequent work at Thames Court and the analysis of all Queenhithe sequences demonstrated a much more complex sequence with Pleistocene gravel sealed by an estuarine clay silt, overlain by a foreshore gravel cut by the AD 198 Roman waterfront. Further river silts, initially predominantly freshwater, but with the strength of the estuarine signal increasing through the deposit, banked up and over the quay and were then sealed by sand and gravel then further silts which predate the AD 950 structures of the second waterfront (Wilkinson 1998). The sequence becomes extremely complex with a series of Saxo-Norman revetments (see Chapter 11.3) with a mixture of estuarine and reclamation deposits.

Sea level analysis has been undertaken along the City waterfront based on archaeological structural analysis (see Chapter 11). One of the earliest studies was at Trig Lane (Milne and Milne 1982, GLSMR 042168, 4 on Figure 85), approximately 400m to the west of Suffolk House. The site involved the excavation of the reclaimed medieval waterfront, which contained a series of timber and stone revetments surviving up to 2.5m in height and dated between the 13$^{th}$ and 15$^{th}$ centuries. On the basis of the revetments, HAT in the 14$^{th}$-15$^{th}$ centuries was calculated at +2.0m OD and LAT at approximately -1.5m OD. HAT was used as it was considered to be at or slightly below occupation levels (Milne and Milne 1982, 61). Analysis of the sediments and biostratigraphy at Queenhithe (Wilkinson 1998) included some discussion of river levels and the position of the tidal head, indicating that there was a weak, (but increasing) estuarine signal in the pre-Roman levels, with an indication for a slight drop in salinity after the construction of the AD 198 quay, but with an increased estuarine signal from the 4$^{th}$ century onwards. The fluctuations in salinity are taken here to represent change in position of the tidal head relative to the site.

In terms of archaeology, the site is centrally positioned within the Roman and medieval cities. Information on the archaeology of the city has been extensively published elsewhere (see MoLAS 2000 for a summary). There is good evidence for prehistoric activity nearby, but this is mainly in the form of artefacts that have been collected (mostly by antiquarians) with little (often dubious) context data recorded, creating an inherently biased and uninformative record. This is exacerbated because it tended to be the attractive and impressive objects that were retained, whilst the less impressive (but more useful) material like pottery and bone will have been discarded. Nevertheless, the information is suggestive. The Neolithic is well represented with a polished axe from Brooks Wharf, Upper Thames Street (GLSMR 041130, 5 on Figure 85), a polished jadeite axe from King Street (GLSMR 041120, 6 on Figure 85) and more stone axes from King William Street

(GLSMR 041117, 7 on Figure 85), Little Trinity Hill (GLSMR 041119, 8 on Figure 85), Queen Street (GLSMR 041121, 9 on Figure 85), Princes Street (GLSMR 041128, 10 on Figure 85), Lower Thames Street (GLSMR 041129, 11 on Figure 85), and Cornhill (GLSMR 041124, 12 on Figure 85). A Neolithic macehead was recovered from Threadneedle Street (GLSMR 041131, 13 on Figure 85) and a battleaxe from Bank (GLSMR 041138, 14 on Figure 85), all of which indicate reasonable amounts of activity in the Neolithic period close to Suffolk House.

The Bronze Age has fewer, but impressive, records with a bronze adze from Thames Court (GLSMR 041139), a bronze dagger from Cornhill (GLSMR 041144), a bronze sword from Custom House (GLSMR 041146, 15 on Figure 85), a spear from St Benets (GLSMR 041147, 16 on Figure 85) and a founders hoard from Queen Street (GLSMR 041153). This last find is important in that it indicates industrial activity likely to have been taking place nearby, rather than just (?ritual) deposition of objects. Surprisingly for this area of London, there is reasonable evidence for an Iron Age presence with La Téne II brooches from Cornhill (GLSMR 041164) and Old Jewry (GLSMR 041165, 17 on Figure 85), a Halstatt D brooch from Lime Street (GLSMR 041166, 18 on Figure 85), an axe from Thames Street (GLSMR 041172), a helmet from Eastcheap (GLSMR 041176, 19 on Figure 85), a spoon from Upper Thames Street (GLSMR 041173) and a coin of the Iceni found on Leadenhall Street (GLSMR 041170, 20 on Figure 85).

Very little stratigraphy of the prehistoric period has been recoded. Some negative features dating to the first millennium BC were excavated nearby at St. Mary-at-Hill (Jeffery et al. 1995, GLSMR 042836, 21 on Figure 85) and on several streets around. Bronze Age features at Gracechurch Street (GLSMR 042541, 22 on Figure 85) and Mesolithic peat from Peninsular House (GLSMR 043489) comprise some of the prehistoric deposits found. There is a tendency for more features to be found on modern excavations such as at Cannon Street (Elsden 2002, 23 on Figure 85), which do not stop digging at the Roman levels; a trait of older excavations in the City.

Modern Suffolk House lies within the so-called Governors Palace complex, a series of extensive and elaborate buildings discovered during excavations in 1969 (Marsden 1975). This consisted of four substantial stone building ranges (with at least 76 rooms) with mosaic, mortar and *opus signinum* floors. The southern range was built just behind the first century waterfront; and was well founded on timber piles. The northern range appears to have been used as a terrace wall, where the natural slope of the gravel had been artificially leveled. No evidence was obtained for the purpose of the central area. Marsden interpreted it as a garden or courtyard. Post Roman use of the site consists of probable Saxo-Norman street creation and alignment during the Alfredian reoccupation of the area, creating Suffolk Lane and Laurence Pountney Lane (the latter thought to be originally called Candlewick Lane) at this date. A church (St Laurence, Candlewick) was established in the mid 12th century (Woodger 1996) and this was later converted to a chantry. Sir John de Pountney built (and subsequently crenellated) a house on the site, consisting of four ranges around a central courtyard between Suffolk and Ducksfoot Lane. The Duke of Buckingham later owned the house until he was executed in 1523, after which the crown held the land. It was granted to the Earl of Devon until he too was executed in 1539. The site, by then known as the Manor of the Rose, subsequently became the Merchant Taylors' school, destroyed along with the church and chantry in the Great Fire of 1666. The school was rebuilt, but the church was not and the resultant space has remained open ground. The rebuilt school was destroyed in the nineteenth century and replaced by offices, partially demolished in 1969 to allow Upper Thames street to be widened.

## The Project

The site was examined under scheduled monument consent during redevelopment of the land. Previous excavations in the area (see above) had revealed significant Roman archaeology in the vicinity, and it was thought likely that the 1st century Roman waterfront would also be found in the new pile positions. Conventional evaluation was undertaken and the potential for archaeological remains was proven. Owing to the significance of the deposits, it was decided by the Corporation of London's planning department to preserve much of the site *in situ*, and only to excavate where absolutely necessary i.e. the new pile positions that were designated 'engineering pits' (EN). A series of small trenches was dug, excavating and recording everything down to the Pleistocene gravel. During this phase of the project, monolith samples were collected from several face sections of the trenches to examine the stratigraphy in more detail. These samples were assessed and indicated an interesting sequence of sedimentation. Several samples were submitted for radiocarbon assay and demonstrated pre-Roman sediments surviving on the site. The Roman sequence has since been published (Brigham 2001). Following the preliminary scan and assessment, the site was selected for analysis on the basis of:

- *The geographical location within the city of London (core area of London for archaeology)*
- *Rare survival of pre-Roman sediments*
- *Evidence for the presence of the first century Roman waterfront on site*
- *Potential to examine use of waterfront structures to reconstruct historic river levels*

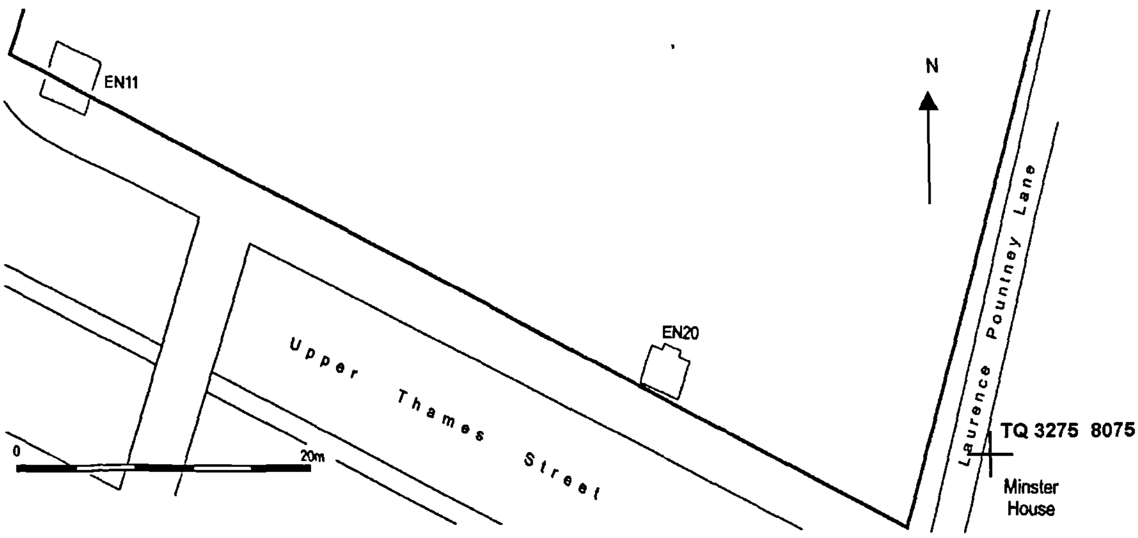



Figure 86. Location of Suffolk House engineering pits within the site outline

## 10.2 The sequence

Two sequences from EN11 and EN20 (sample 56 and 72 respectively) were described (see Appendix 7, Tables 85 and 86). The sequence in EN11 is of the Shepperton Terrace overlain by organic clay silt sealed by Roman deposits. EN20 consists of waterlain clay overlain by further organic muds, again sealed by Roman deposits. This section contains a summary description and interpretation, whilst the raw data may be found in Appendix 7.

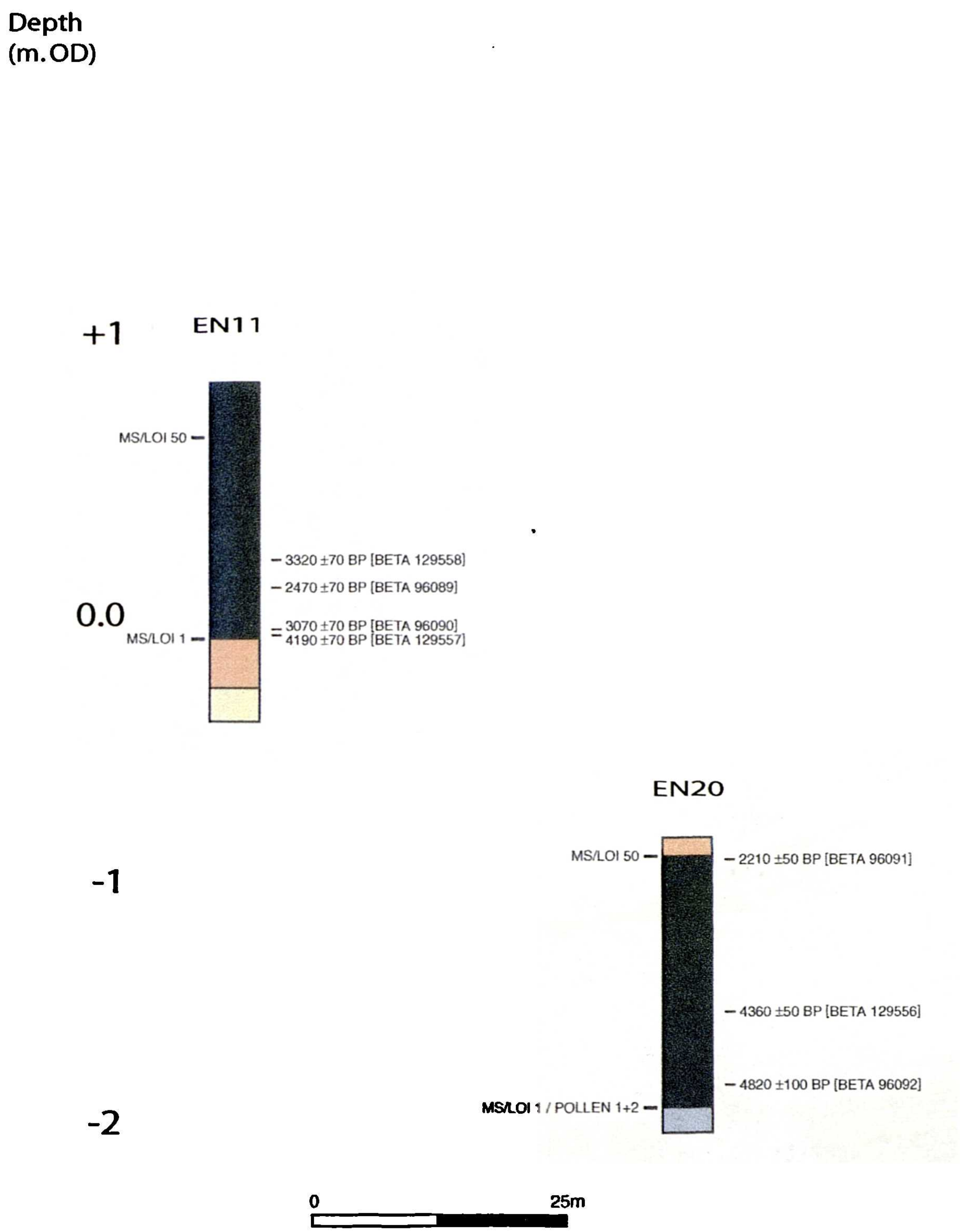



Figure 87. Suffolk House Lithological diagram

### Sequence 56, engineering pit 11

The sampled sequence starts at -0.46m OD with sand and gravel, which is overlain by a sand silt that fines upwards and incorporates some organics. This persists to -0.33m where it is overlain by a finer clay silt with more organic material. It is sealed by a coarser deposit from -0.29m, with gravel within the matrix, but still containing organic matter.

The gravel is likely to have been redeposited, possibly further up the gravel slope to the north. A radiocarbon date of 3070±70 BP (Beta 96090; 1520-1130 cal BC) (see Appendix 7, Table 92) was obtained from -0.23m OD. From -0.13m to +0.87m, the sequence consists of organic muds, on the whole, fining upwards. A second date was collected towards the lower part of the organic mud; 2470±70 BP (Beta 96089; 790-400 cal BC, +0.17m OD), covering the Early Iron Age. There is a slight coarsening of the sediment at *c.* +0.50m OD that could be a result of a flooding event across the site. Wood is present throughout, with some rooty vegetation, suggesting *in-situ* growth. This deposit was mixed with domestic Roman material at +0.80m OD and all was sealed by timbers forming the tiebacks of the second waterfront (Quay 530, dating to approximately AD84. A series of timbers from this structure were dated, and spring AD 84 (Tyers 2001, see Appendix 7, Table 91) is the latest date obtained and comes from a timber with bark present. The magnetic susceptibility values were generally low throughout (see Appendix 7, Figure 187); giving no indication of localized magnetic enhancement that might have resulted from human agency except possibly at the top of the sequence where $\chi^{lf}$ values reach 15 $m^3 kg^{-1}$.

### Sequence 72, engineering pit 20

This sequence can be broadly classified as one deposit. The underlying sediment could not be sampled owing to water ingress, but was noted as a grey clay silt, present below -2.05m OD, the interface 50mm below the point where sampling began. The sampled sediment consists of organic mud; mainly silt clay, with a small proportion of sand above the lowest two units. The organic matter is mainly unidentifiable, although small quantities of detrital wood were noted almost entirely throughout. Unfortunately, no diatom valves were recovered from any of the samples taken from this site. Several pollen samples were assessed from the base of the sequence by Dr. Rob Scaife (see Appendix 7, 7.3), indicating an alder carr type environment with local woodland, presumably slightly upslope to the north.

Figure 88. Roman quay (waterfront 2), Suffolk House EN11 (0.5m scale)

At the base of the sequence, at -2.0m, total organic carbon is only 4%, but gradually increases. By -1.64m OD, it has reached 50% and stays fairly constant for a further 0.2m until it drops to *c.* 30%. This persists until -1.14m OD where again the percentage goes above 50% and remains consistent until the top of the sampled sequence (see Appendix 7, Table 90). This suggests fairly limited fluctuation in the conditions, with several periods where water incursion across site was stronger, but these could have been extremely short-lived events. Figures obtained by Zong and Horton (1998, 1999) indicates the possibility that an organic mud forming in an estuary giving TOC values of approximately 50% is likely to be forming at or slightly above approximately MHWST. No major changes are apparent in the magnetic susceptibility samples, all of which give low values.

Three radiocarbon dates were obtained from this sequence. A sample towards the base, at -1.83m OD, dates to 4820±100 BP (Beta 96092; 3900-3350 cal BC) whilst the very top of the sequence was dated to 2120±50 BP (Beta 96091, 260-30 cal BC, -0.9m OD). These span the Early Neolithic to the Late Iron Age, a long period for an accumulation of only 1m, which could indicate compression and /or periods of stasis or erosion. The third sample was taken later to confirm the rather unexpected dates, which gave a result of 4360 ± 50 BP (Beta 129556; 3100-2890 cal BC, -1.69-1.64m OD). The upper levels of the organic mud were cut by Roman timbers (684 and 685) from -1.05m OD. The timbers form part of waterfront three, a post and plank revetment of rather poorer build than waterfront two. Although some of the timbers have been re-used, a date of AD 100-120 has been obtained for the structure (Tyers 2001). Foreshore deposits seal the organic mud at *c.* -0.6m OD, which is thought to represent contemporary MLWST, indicating a rise in relative river levels since the Late Iron Age.

The sequence indicates that the depositional environment is likely to have been one with aquatic inundation of an energy low enough not to disturb the vegetation apparently growing *in-situ,* which may account for the long chronology of the deposit. No evidence of orientation was observed within the sediment (observed by eye and x-radiograph) to indicate which direction the clay silt component came from, but it seems likely that the it came from the Thames, or possibly the confluence of the Thames and the Walbrook Stream, which is thought to have been approximately 50m to the west.

### The Waterfronts

Evidence for four distinct waterfronts is present at Suffolk House. The first was in the form of a few undated piles present in EN11 (*c.* -1.0m OD), thought to be part of a jetty south of the AD 50 riverbank (waterfront 1), located to the north of EN11 and EN20. The location is based on extrapolation of previously calculated MHW in AD50 of approximately 1.2m OD (Brigham and Woodger 2001, 17). The piles in EN11 must date to between AD 43 (date of Roman invasion) and AD 84 (waterfront 2, which overlies waterfront 1). The presence of a jetty, if an accurate conjecture, indicates that the location of the 1.2m OD contour was not useable for boats.

The second waterfront, (late 1st century), was a professionally built structure. Tiebacks for the quay were present in EN11 (see Figure 89), but not the actual quay frontage. It is not thought to have been robbed and survives to 2.15m OD - slightly higher than other first century quays. The construction is of green oak indicating the felling date of AD84 must give the construction date to within a year, with a series of piles and locking bars maintaining a solid structure able to retain the frontage against the river and against the reclamation/landfill behind it.

The third waterfront (present in EN20) appears less solidly built, formed of a post and plank revetment incorporating previously used timber in the lower sections. Its height is thought to have been 1.5m OD (some damage is present to the top of the posts) with the base at -0.45m OD. The construction date is calculated at approximately AD 120 (Tyers 2001), indicating a drop of approximately 0.6m in the working height of the waterfront over a period of some 35 years. This could stem from a miscalculation in optimum location for the AD 84 quay, or a drop in RRL. It seems unlikely that the first century quay was wrongly positioned because the Roman occupation and quay building began in at least AD 52, on the basis of the timbers from Regis House (Brigham et al. 1996, 24 on Figure 85), therefore, significant experience of the Thames would have been accrued by AD 84. This leaves a drop in river level as the most likely explanation.

Although not found on the site, a fourth waterfront is thought to have been present, on the basis of infilling to the south of the post and plank revetment and data gathered in the RCHME survey of 1928 (Wheeler 1928, 143). It is difficult to date the construction of the fourth waterfront, owing to the varied nature of the artefacts in the fills. The pottery suggests a range between AD 120-60, however, a timber drain cutting through waterfront three has a dendro date of AD128, indicating that the quay was no longer functioning at this date and the waterfront had moved to the south. There is, unfortunately, no information as to the height of the working surface of the fourth quay. However, the evidence from sites such as Regis House (Brigham et al. 1996) indicates that the waterfront at this date continued to drop.

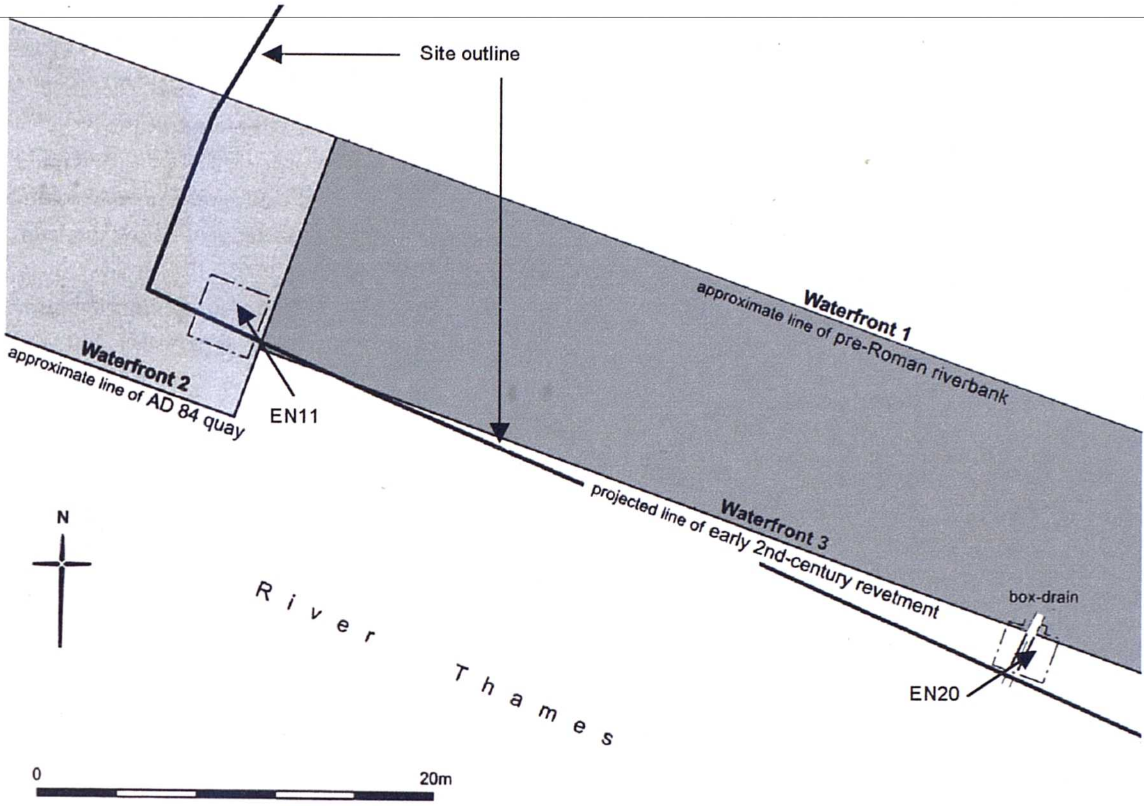



Figure 89. Projected line of waterfronts, adapted from Brigham and Woodger (2001)

## 10.3 Site summary

Although the sedimentary sequence at Suffolk House is a relatively short one that did not produce any diatom valves, it has some important points. Firstly, it is an extremely rare example of prehistoric organic sedimentation on the north bank of the Thames in the City. This has only been found once before, at Peninsular House, in almost a century of (reasonably) controlled excavation in the area. Furthermore, the peats span the Neolithic to Bronze Age, fitting well with the deposits further downstream (see Chapter 11). An interesting point about the peat is the presence of a *Taxus baccata* pollen grain in the lower deposits. As has been discussed above, there are issues with the taphonomy of *Taxus* pollen, and even sporadic presence may indicate a much larger community. If this were the case, it would be the most westerly (and possibly earliest) evidence for the *Taxus* community better represented downstream. Nevertheless, one grain does not a forest make.

The link of the peat to the Roman waterfront is also an important aspect of this site. The peat is sealed by foreshore deposits, into which the Roman quay is cut. The quays provide good evidence for river levels in the 1st and 2nd centuries AD, and their position indicates a drop in river levels between these dates of *c.* 0.6m. The first quay here dates to AD 84, well after the founding of the town and the build of the first city quay (dated at nearby Regis House to AD 52), and therefore, it is not simply a case of the first Suffolk House quay being in the *wrong* place. This gives more credence to the evidence from this site suggesting that water levels are indeed dropping.

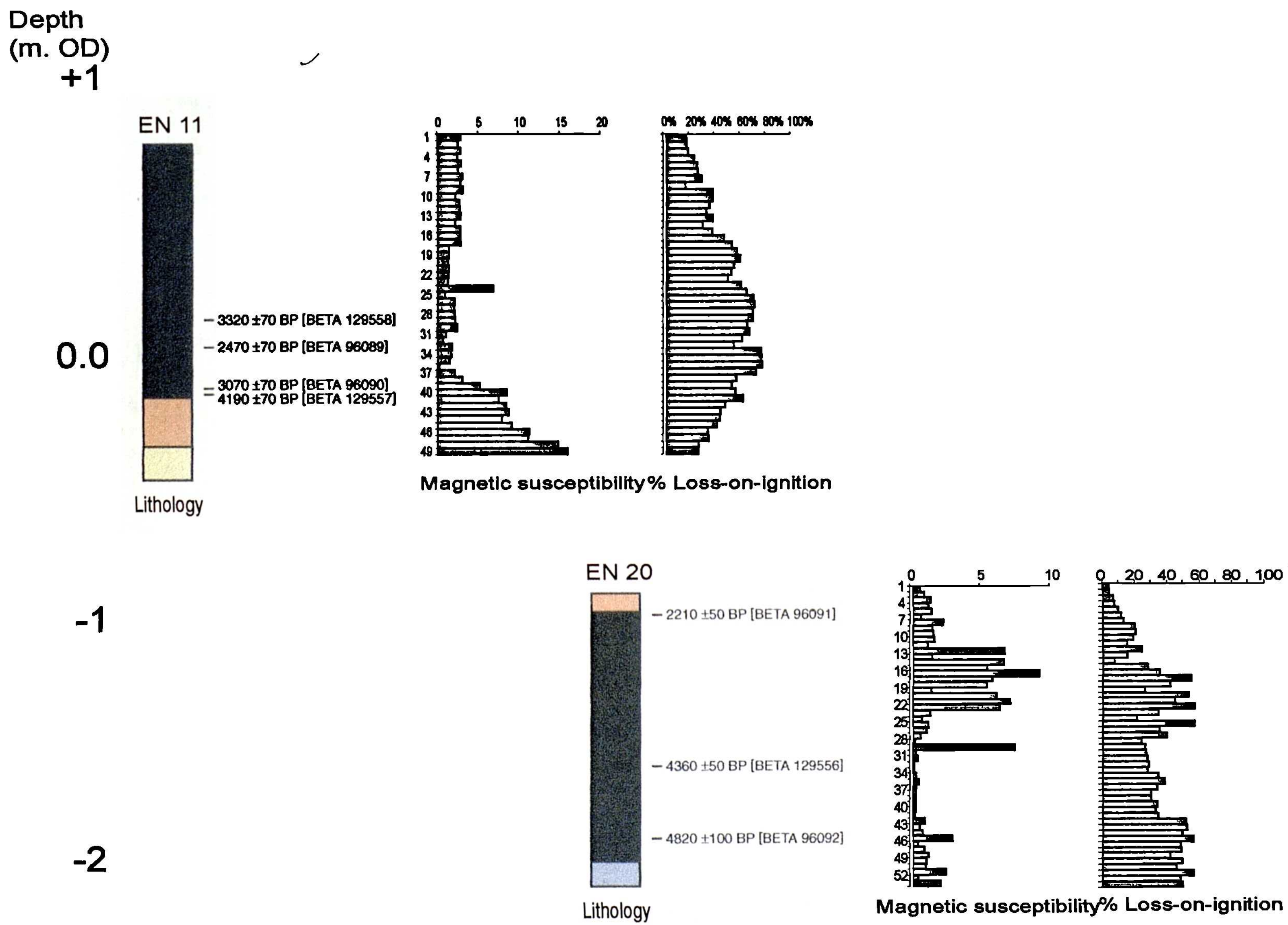



Figure 90. Suffolk House summary diagram

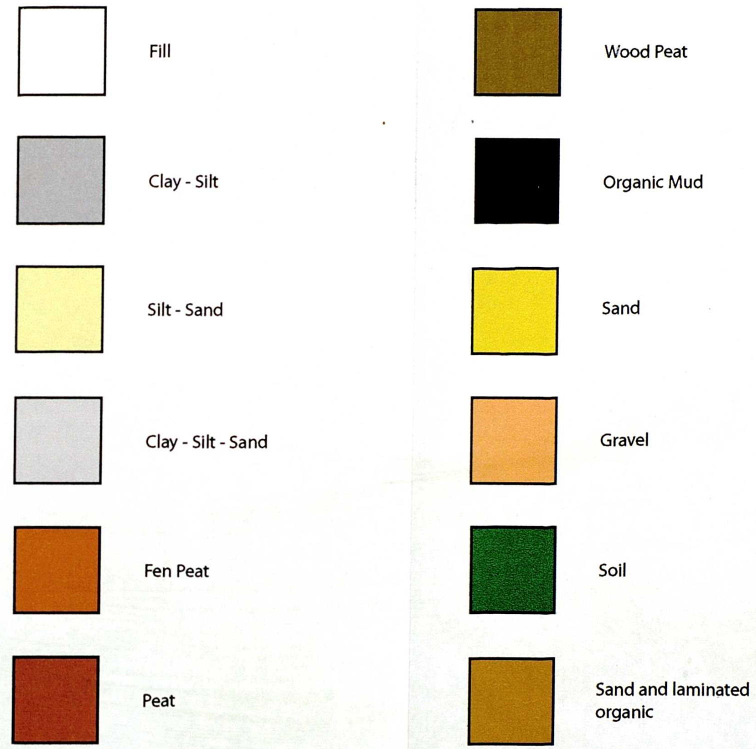



**Figure 91. Key to stratigraphic and lithological diagrams**

# Section III: Analysis

## *Introduction*

This section contains a discussion of the data collected to examine the aims and objectives outlined in Chapter 1, using the individual sites outlined in Section II and other data from within the estuary. The issue of sea level change is taken first, with an examination of tendency, age-altitude calculation and finally through archaeological means. Comparison is made with several other estuaries in southern England, particularly the Severn. Following the discussion of RSL is an examination of the pattern of human occupation and activity within the floodplain. The key question addressed is whether there is any noticeable response of the human population to the changes in estuary and floodplain configuration.

# Chapter 11. Sea level change

## 11.1 Tendency

### Introduction

The concept of using tendency of sea level movement as an analytical tool has been outlined above (Chapter 2) and is considered here in reference to the sites discussed in Section II. The chronological tendency exhibited at these sites (see Figures 93 and 94) is also considered in reference to the model published by Devoy (1979, 1980) and more recently by Long et al. (2000) (see Figures 95 and 96, also Table 27).

### Results

There is no clear pattern expressed in the basal deposits recorded in the cores; on the whole, there is some evidence for an initial positive tendency of movement in the deposits resting on the Pleistocene gravel, driven upward by a rising watertable. This is not the case at Silvertown (1 in Figure 92), which is the result of organic deposition in a relict Devensian freshwater channel, cut off from the contemporary Thames and protected from subsequent erosion, however, these points do not express tendency of movement at this date. There is also evidence for a negative tendency of movement at the base of some sequences at Gallions Reach (2 in Figure 92). However, the general pattern is for inorganic sedimentation above gravel. The onset of this phase of deposition is not well dated owing to the sediment type and lack of suitable organic material for dating. A date from Masthouse Terrace (3 in Figure 92) of 10090±80 BP (Beta 85221; 10330-9310 cal BC, -5.85 OD) shows the onset of inorganic sedimentation, however, this is thought also to be in protected environment and well above contemporary RSL. There is only limited biostratigraphical evidence from these initial silts, and then it tends to come from within the upper levels; but a clear picture of estuarine contact is shown at Wennington, Voyagers Quay, North Woolwich (4-6 in Figure 92) and Masthouse Terrace from the 5$^{th}$ to 4$^{th}$ millennia cal BC.

It is much easier to date the end of this initial phase of positive tendency with the earliest date for a regressive overlap from Masthouse Terrace; 5950±80 BP (Beta 85220;

5040-4620 cal BC, -4.35m OD). This date comes from slightly into peat, and is therefore a *terminus ante quem* for peat initiation. The youngest date for this regressive overlap comes from Wennington Marsh, the most downstream of the Section II sites; 5010±70 BP (Beta 76903; 3960-3650 cal BC) at an altitude of -2.55m OD. It is thought that the expansion of the peat-forming wetlands occurred at this time because of a rising watertable in combination with a decrease of the upstream movement of tidal waters. This need not have been an actual reduction in RSL, but rather a decrease in the *rate* of rise in RSL, commensurate with deceleration following the initial Holocene surge in RSL.

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Silvertown | 4050 | 8035 |
| 2 | Gallions Reach | 4490 | 7985 |
| 3 | Masthouse Terrace | 3750 | 7850 |
| 4 | Wennington Marsh | 5425 | 8025 |
| 5 | Voyagers Quay | 4730 | 8130 |
| 6 | North Woolwich | 4345 | 7985 |
| 7 | Suffolk House | 3271 | 8077 |
| 8 | Tilbury | 6466 | 7540 |
| 9 | Dartford | 5675 | 7600 |
| 10 | Crossness | 4815 | 8015 |
| 11 | Woolwich East | 4462 | 7988 |
| 12 | Church Manor Way | 4662 | 7988 |
| 13 | Beckton 3-d | 4270 | 8200 |
| 14 | Beckton Nursery | 4260 | 8200 |
| 15 | Beckton Alp | 4310 | 8210 |
| 16 | Beckton Tollgate | 4270 | 8160 |
| 17 | Beckton Sewage Farm | 4500 | 8200 |
| 18 | Bargehouse Road | 4380 | 7990 |
| 19 | Albert Road | 4325 | 7990 |
| 20 | Joan Street | 3160 | 8010 |
| 21 | Thomey Island | 3022 | 7962 |
| 22 | Wilsons Wharf | 3314 | 8023 |

Table 24. Sites shown on Figure 92

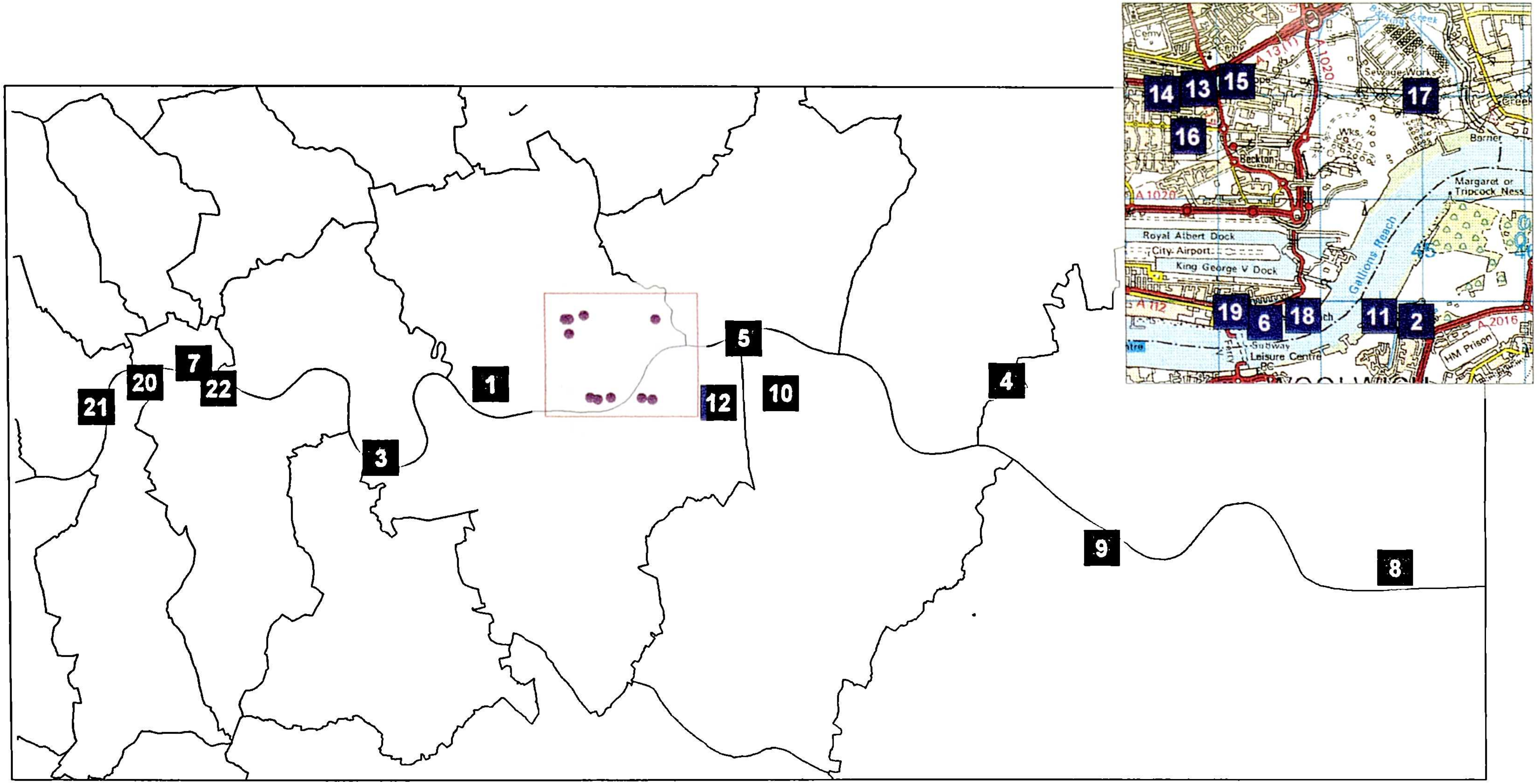



Figure 92. Location map of London sites mentioned in chapter 11.1

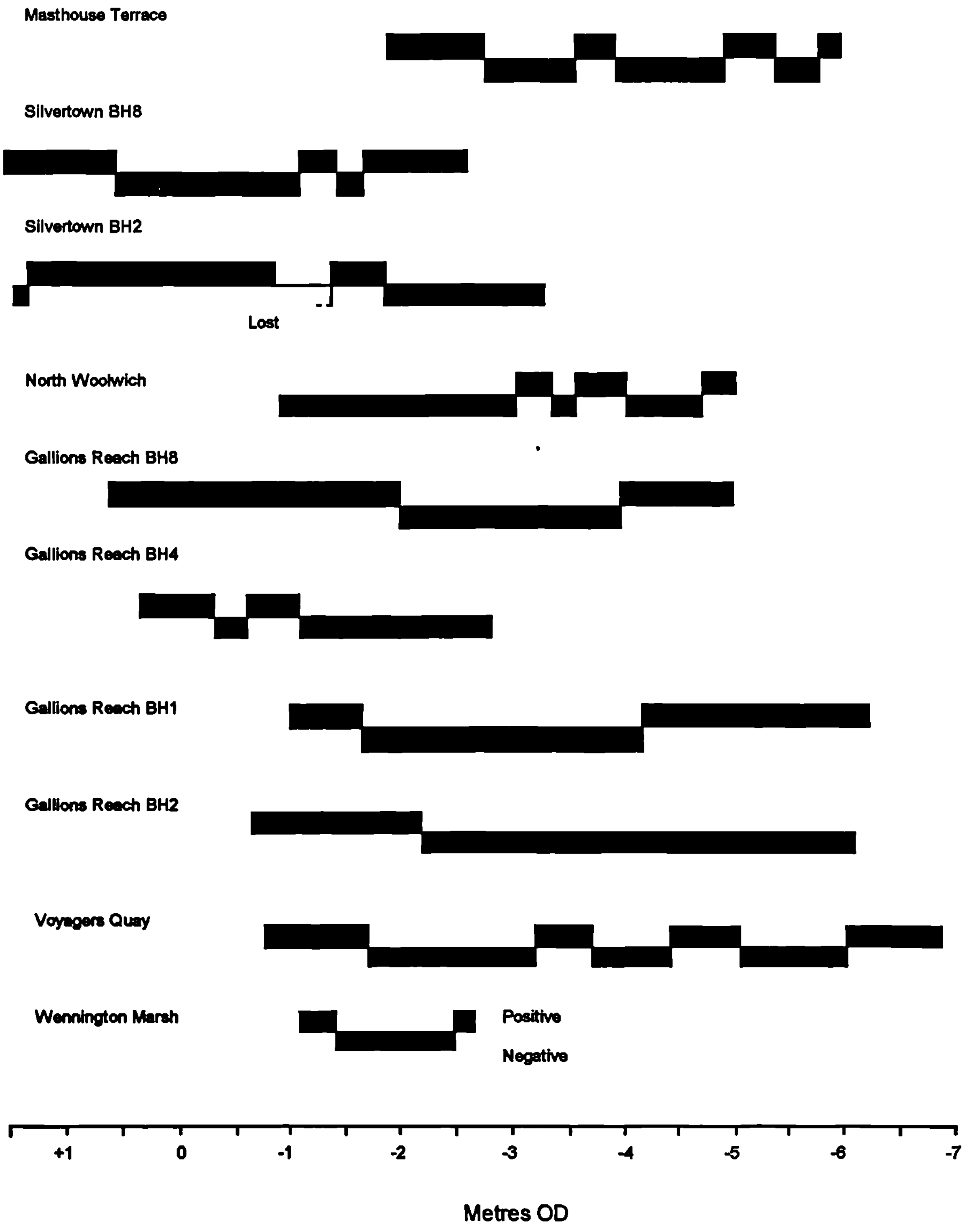
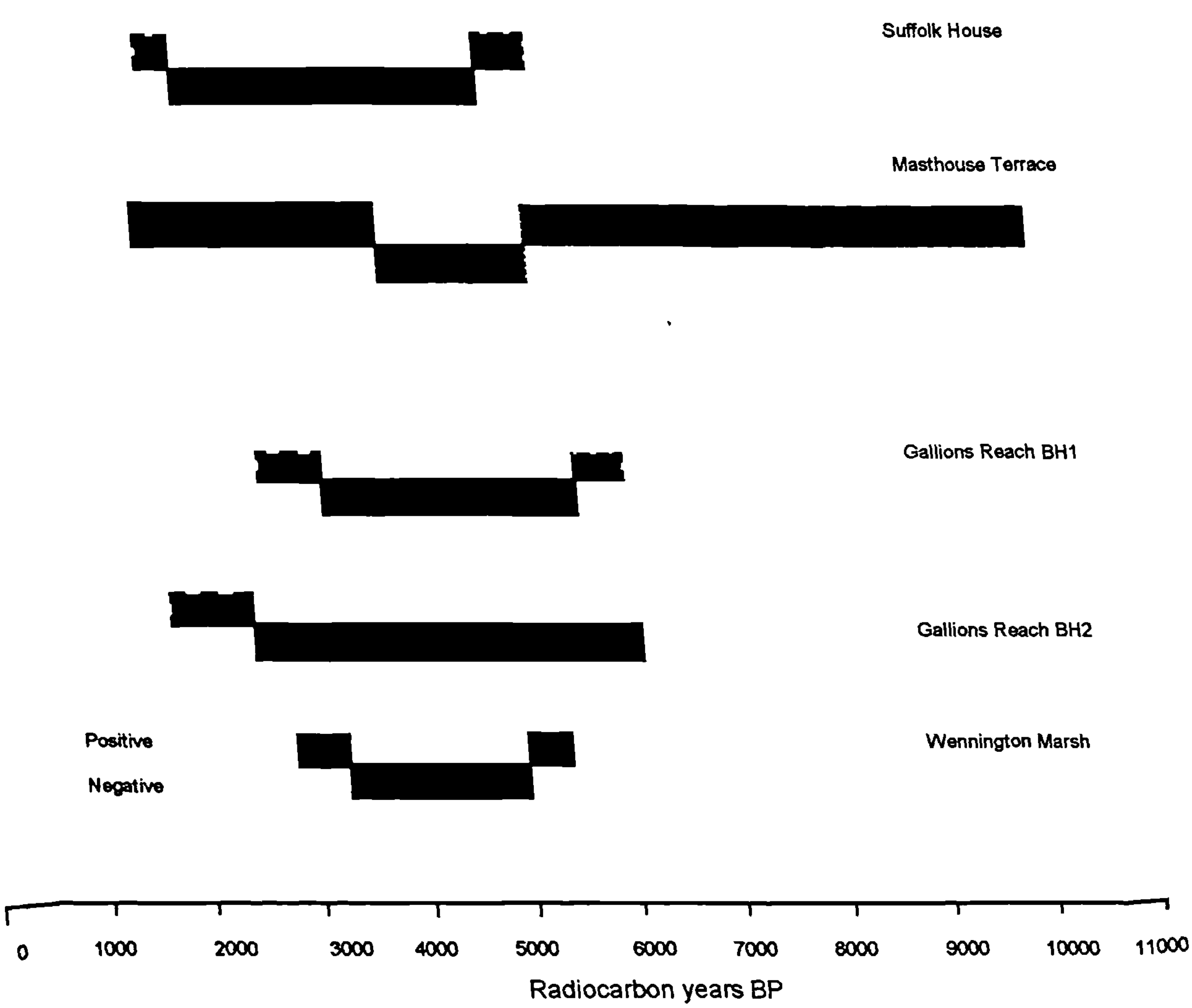



Figure 93. Tendency bars for selected cores (by depth)




Dashed line = undated

Figure 94. Tendency bars for selected cores (by age)

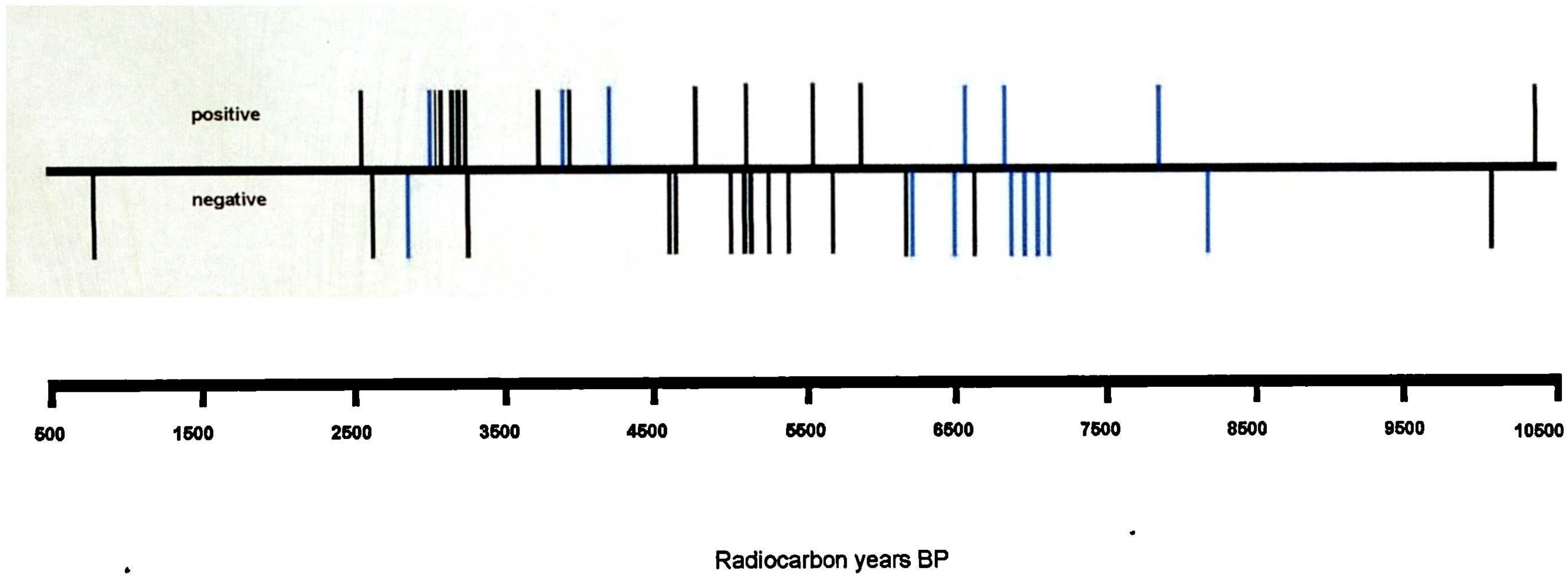
There is much local variation in deposition during this period of wetland expansion, with a series of peats and organic muds at some sites, such as Voyagers Quay and North Woolwich, which may be a result of the sites being situated relatively close to the main tidal channel and therefore more prone to change in local sedimentary process. However, there is a pattern present in many of the sequences of initial minerogenic sedimentation, followed by organic deposition (with an estuarine influence during organic accumulation, for example at Wennington and Voyagers Quay), sealed with a widespread transgressive overlap. For the purposes of the discussion of tendency, the general pattern will be examined, and the local complexities of sedimentation will not be considered here.

The timing of this widespread negative tendency is recorded first at the upstream site of Masthouse Terrace, and followed nearly a thousand radiocarbon years later by a regressive contact at Wennington. The peat takes the form of a wood peat ubiquitously throughout the study area in this period, which indicates a significant expansion of the wetlands over previously brackish/estuarine silts. The exact nature of the wood peat varies, with evidence for alder carr and also the yew woods found at Wennington and North Woolwich. Although not recorded from the sites of Voyagers Quay and Gallions Reach, the records of Spurrell (1885, 1889) suggest that the peats in Thamesmead were also derived, in part at least, formed from this extensive yew woodland. What is apparent is that the water table continues to rise during this period, with the wood peat replaced by a sedge fen, generally towards the top of the major peat beds. Where diatom evidence is available from within the peat (Voyagers Quay, Gallions Reach, North Woolwich) the assemblages indicate that brackish/marine and fresh waters were feeding into the marshes and woody peat-forming habitats during peat accumulation.

The earliest date for the end of peat formation is at Gallions Reach, 3240±70 BP (Beta 100877; 1690-1320 cal BC, -1.7m OD), which is statistically indistinguishable from a comparable date and transgressive contact at Wennington; 3220±70 BP (Beta 76902; 1680-1320 cal BC at -1.33m OD). The peat continues forming at Suffolk House (7 in Figure 92), in the City until 2210±50 BP (Beta 96091; 260-30 cal BC at -0.95m OD) where the Early Roman foreshore seals it. These dates show that the inundation of the peats occurred approximately a thousand radiocarbon years later in the City than downstream at Wennington (see Table 25).

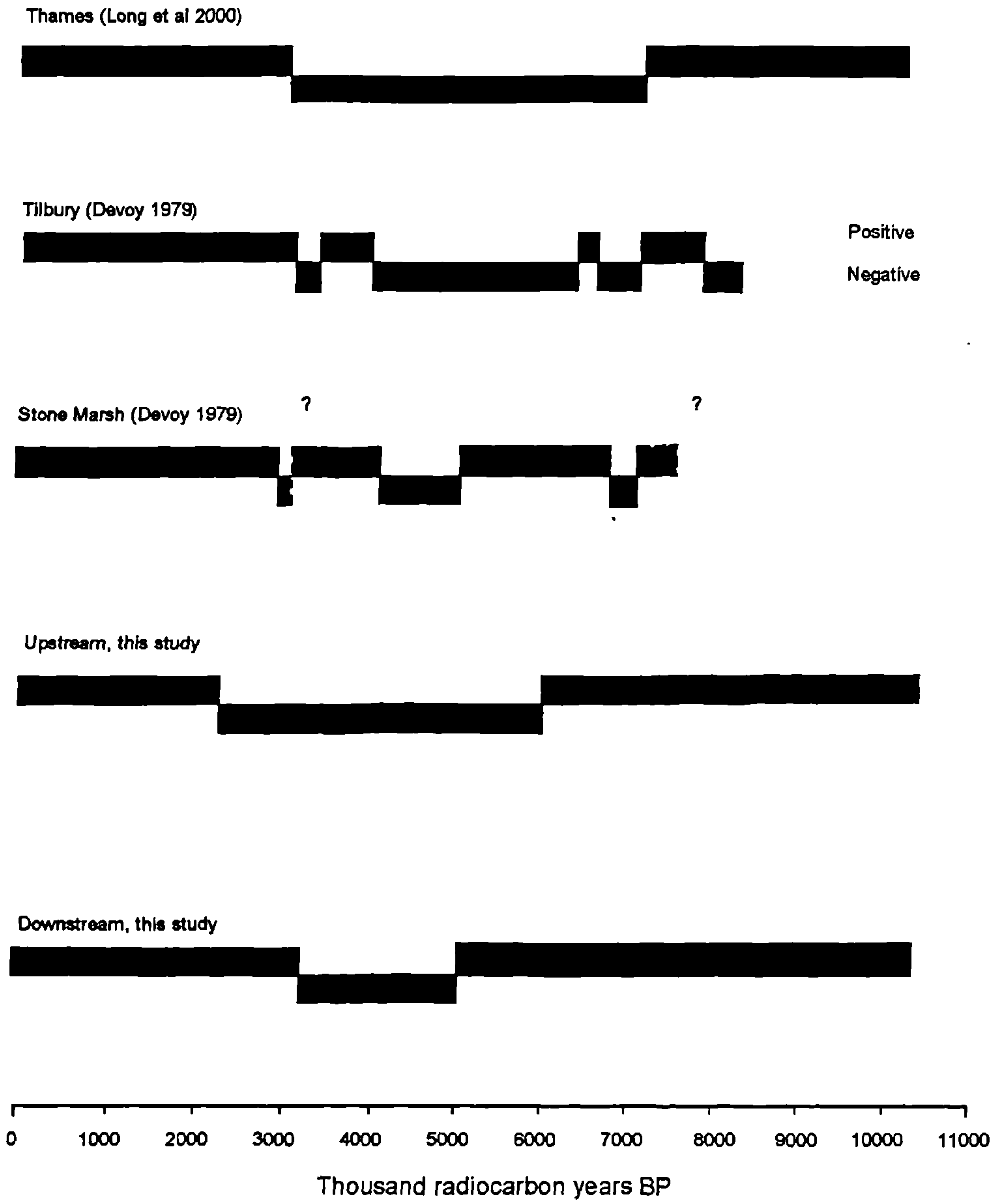
This phase of positive tendency is present at every site (seen in the field but not possible to sample at North Woolwich). However, very little dating evidence is available owing to the sediment type. It is impossible to date at Suffolk House owing to the anthropogenic modification of the waterfront in the Early Roman period. One date is available from Silvertown, where a small organic horizon within the silts was dated, giving a result of 750±60 BP (Beta 93681; 1160-1400 cal AD at +0.76m OD). At the downstream extent, the undeveloped area of Wennington Marsh is currently protected by river defences, otherwise it might still accumulate mineral sediment from the river, however, there has been local reclamation and drainage, which has almost certainly reduced the levels of land (Chandler 2001).

In comparison with the model of Devoy (1979), there is very little similarity between this chronology and his published ones. Much of his model is based on the dataset from Tilbury (8 *in* Figure 92), which is *c.* 11km downstream from Wennington, and a further *c.* 28 km from the City. The deposits'at Tilbury are also at much greater depth and, in terms of the organic formation, are 2000 radiocarbon years earlier, so the differences between the present study and the actual Tilbury sequence are not surprising. A closer examination of the individual sequences shows that there is indeed some similarity in terms of straightforward sequence and possibly tendency of movement. Wennington Marsh is only slightly upstream of Dartford (9 in Figure 92) where a negative tendency of movement can be dated to 4930±110 BP (Q1336; 4000-3500 cal BC) at a depth of -2.99m OD. This compares with well with 5010±70 BP (Beta 76903; 3960-3650 cal BC, 2.5m OD), the date of the regressive overlap at Wennington. However, Devoy's sequence at Crossness (10 in Figure 92) does not compare well in terms of dating, although the general stratigraphic sequence (and that at Woolwich East and Church Manor Way, 11-12 in Figure 92) agrees reasonably well with the Gallions Reach sedimentology. In fact, if the actual sequence from Tilbury itself could be abandoned, the model would be broadly comparable with these new results from further up the estuary.




Blue bars = dates taken from Devoy (1979)

Figure 95. Radiocarbon dates from the study area used in tendency analysis




? = date of change uncertain
dashed line = uncertain date

Figure 96. Synthetic tendency bars for the study area compared with the work of Long et al. (2000) and Devoy (1979)

| Phase | Type/location | $^{14}C$ years BP | Calendar years BP | Calendar years BC | Cultural periods |
|---|---|---|---|---|---|
| I | Positive (upstream) | >5950 - 5950 | >6750 - 6750 | >4800 – 4800 | Mesolithic |
| I | Positive (downstream) | ≥5010 - 5010 | ≥5750 - 5750 | ≥3800 – 3800 | Mesolithic - Neolithic |
| II | Negative (upstream) | 5950 - 2210 | 6750 - 2100 | 4800 – 150 | Mesolithic - Iron Age |
| II | Negative (downstream) | 5010 - 3240 | 5750 - 3450 | 3800 - 1500 | Neolithic - Bronze Age |
| III | Positive (upstream) | 2210 - | 2100 - | 150 - | Iron Age - modern |
| III | Positive (downstream) | 3240 - | 3450 - | 1500 - | Bronze Age - modern |

Table 25. Proposed tendency phases for the inner Thames, based on this work.

Elsewhere in the eastern floodplain, a similar tripartite tendency pattern may be seen. In many cases, the base of the peat was not reached, owing to the depth and the fact that much of the peat has been seen in archaeological trenches rather than boreholes. Nevertheless, the image of one substantial peat, sealed from the mid Bronze Age is seen commonly over northeast London, for instance at Beckton (see Table 26 and 13-17 in Figure 92) where a series of sites have shown one major peat bed between mineral sediment. These have not been analyzed in detail or published, however, the stratigraphy has been described in detail and radiocarbon dates have been obtained from the top and bottom of the organic sequences. What these show is a wood peat replaced by an alder carr (Scaife 1997), in some cases with mid Bronze Age trackways at the top of the organic sequences. In terms of date, the peat starts forming earliest at the northern edge of the floodplain and latest closest to the channel, taking approximately 1500 years to do so. This is approximately reversed for the inundation of the peat, with Beckton sewage farm inundated first in the mid Bronze Age, followed progressively by the sites to the north over a period of roughly a millennium, suggesting the inundation was more rapid than the wetland expansion.

| Site | Lab code | m. OD | Measurement ($^{14}$C years) | Stratigraphic position | Calendar years BC |
|---|---|---|---|---|---|
| Beckton 3-d | Beta 68579 | - 4.5 | 5640 ± 70 BP | Base of peat | 4680-4340 |
| Beckton Nursery | Beta 76883 | c. – 4 | 5660 ± 60 BP | Base of peat | 4670-4360 |
| Beckton Alp | Beta 80893 | -3.50 | 5430 ± 70 BP | Base of peat | 4345-4230 |
| Beckton Tollgate | Beta 76887 | -2.5 | 4720 ± 70 BP | Base of peat | 3650-3350 |
| Beckton Sewage Farm | RCD 2183 | -1.8 | 4240 ± 60 BP | Base of peat | 2920-2620 |
| Beckton Sewage Farm | RCD 2182 | c. – 0.7 | 3220 ± 60 BP | Top of peat | 1620-1330 |
| Beckton Alp | Beta 80892 | -1.5 | 3090 ± 60 BP | Top of peat | 1415-1280 |
| Beckton 3-d | Beta 103105 | c. - 1.5 | 2330 ± 70 BP | Top of peat | 800-200 |
| Beckton Nursery | Beta 76884 | -1.30 | 2360 ± 60 BP | Top of peat | 540-250 |
| Beckton Tollgate | Beta 76888 | -1.0 | 2160 ± 70 BP | Top of peat | 380-5 |

Table 26. Radiocarbon dates from the Beckton peats, unpublished data from the Newham Museum archive

In North Woolwich at Bargehouse road (18 in Figure 92), a similar pattern is present, of estuarine mineral sedimentation with one substantial peat unit dating from 5240±70 BP (Beta 148290; 4240-3945 cal BC, -3.4m OD) to 3280±50 BP (Beta 148291; 1680-1435 cal BC, -1.0m OD), which is sealed by estuarine mineral sediment (Corcoran 2001). This is closely matched at Albert Road (19 in Figure 92) nearby with the estuarine silts, peat and then more estuarine silt, with the peat dating to between 6020±60 BP (Beta 149599; 5050-4760 cal BC, -4.3m OD) and 3010±60 BP (Beta 149598; 1410-1040 cal BC, -0.7m OD) (Spurr 2001).

The trend of one peat intebedded between mineral sediment is seen as far upstream as Lambeth (Sidell et al. 2000) and also north Southwark (Tyers 1988). From Lambeth, the sequence at Joan Street (20 in Figure 92) showed peat present above freshwater silts and dated to (slightly earlier than) 4850±80 BP (Beta 119783; 3790-3380 cal BC, -2.3m OD), sealed at 2340±60 BP (Beta 119784; 760-210 cal BC, -0.55m OD), slightly earlier (and higher) than the end of organic formation at Suffolk House, slightly downstream. The pattern at Joan Street is more widely mirrored in the area and on Thorney Island (Thomas et al. in prep, 21 in Figure 92).

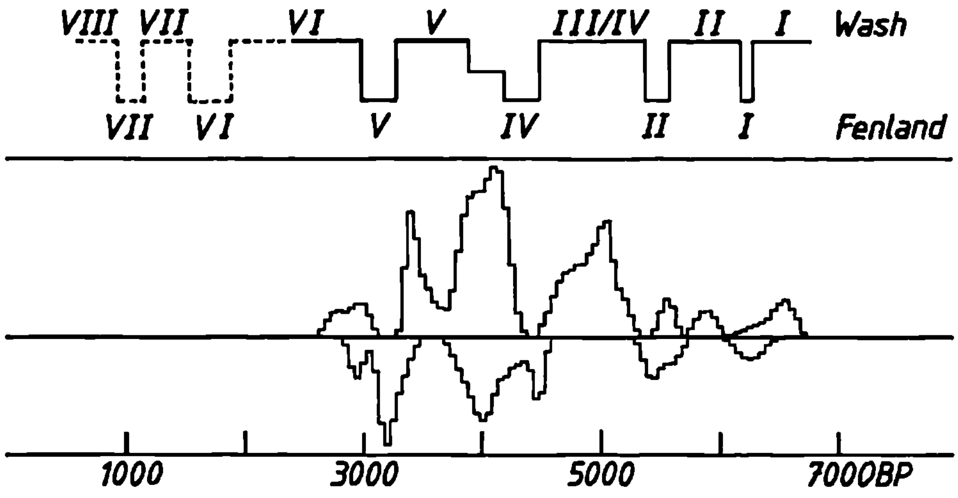
The data from north Southwark is interesting in that this was initially published as an analogy to Tilbury IV, but examination of the sequences shows that they fit more closely with the end of the one key period of peat formation postulated here for the inner estuary. The majority of Tyers' samples date to the Late Bronze Age/Early Iron Age, between 3010±70 BP (HAR-3925; 1420-1020 cal BC, 0.1m OD) and 2570±80 BP (HAR-3927; 900-400 cal BC, 0.38m OD). This latter date from Wilson's Wharf (22 in Figure 92) (which records the submerging of a sedge peat) is 370 radiocarbon years earlier than the sealing of the peat at Suffolk House, which is approximately 500m upstream and so sits well within the pattern suggested above.

The sequences from Thorney Island exhibit some similarities with those in the City and Southwark; Bronze Age peats and organic muds have been found around the margins of the eyot, in all cases sealed by estuarine sediment, with extensive diatom assemblages (Sidell et al. 2000, chapter 4). The organic muds start forming after *c.* 1600 cal BC (*c.* -0.2m OD) and persist until around 700 cal BC. The deposits are sealed earlier than at Suffolk House, and indeed occur approximately a metre higher. The influence of the Tyburn River may have contributed to the organic mud being sealed earlier, but it is more likely that the erosion noted on Thorney Island (Sidell et al. 2000, chapter 4) has stripped some of the organic deposits. This erosion is thought to have occurred sometime between the beginning of the Iron Age and the 12th century, possibly a result of storms noted elsewhere in the Saxon period (Watson et al. 2001) or the building of the Colechurch London Bridge. The difference in altitude is more difficult to explain; the heights of the organic mud are more consistent with those in Southwark, i.e. at or a little above OD, so it is possible that the discrepancy lies at Suffolk House and could be a factor simply of the low position on the foreshore at Suffolk House whereas the others may be at, for instance MHWST.

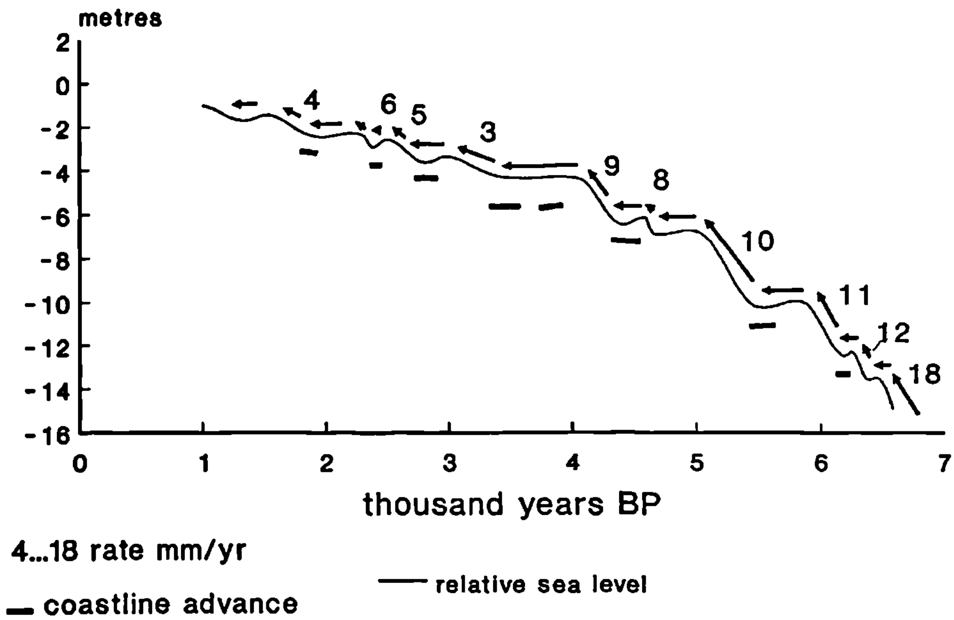
## Regional comparisons

Moving outside the Thames into southern Britain, tendency analysis has been undertaken, albeit on a rather limited scale. Work by Shennan (1980, 1982, 1986b) in the Fenlands (see Figure 98) indicates where a chronology of *Wash* (positive tendency) and *Fenland* (negative tendency) has been constructed. Seven positive and 6 negative periods of movement were identified, starting with Wash I from *c.* 7000 radiocarbon years BP (see Figure 97a). Wash I, II, III and IV (*c.* 7000-4500 radiocarbon years BP) are in fact only interspersed with two short negative phases until Fenland IV , which is more substantial, occurring from *c.* 4500-3900 radiocarbon years BP. This is succeeded by another positive tendency of movement of similar duration. Fenland V, occurring between *c.* 3200-3000 radiocarbon years BP. The data following this phase are not well resolved, but indicate a long period of RSL rise (Wash VI, VII and VIII) with several more periods of wetland expansion. The Fens would seem to be primarily dominated by periods of positive tendency, with only short lived periods of peat expansion and would seem to indicate that other controlling processes are active in the Fens compared to the Thames.

The model was subsequently slightly modified (Shennan 1994), to take an eighth negative tendency into account (see Figure 97b). It should be noted that there is some disagreement between Shennan and Waller (1994a, 81) on the exact sequence of the negative tendencies. Palaeogeographic mapping of the Fenland lithology and biostratigraphy indicates that the area was almost continually facing RSL rise with only a few phases of regional negative tendency. Waller identifies the first clear evidence from *c.* 3800 cal BC (very similar to the Thames), with several subsequent phases, notably during the Roman period, between *c.* AD150-300, again, showing strong parallels with the Thames.




a)




b)

Figure 97. Tendency diagram of the Fenland sequence (radiocarbon years BP),

a) from Shennan (1982)

b) from Shennan (1994)

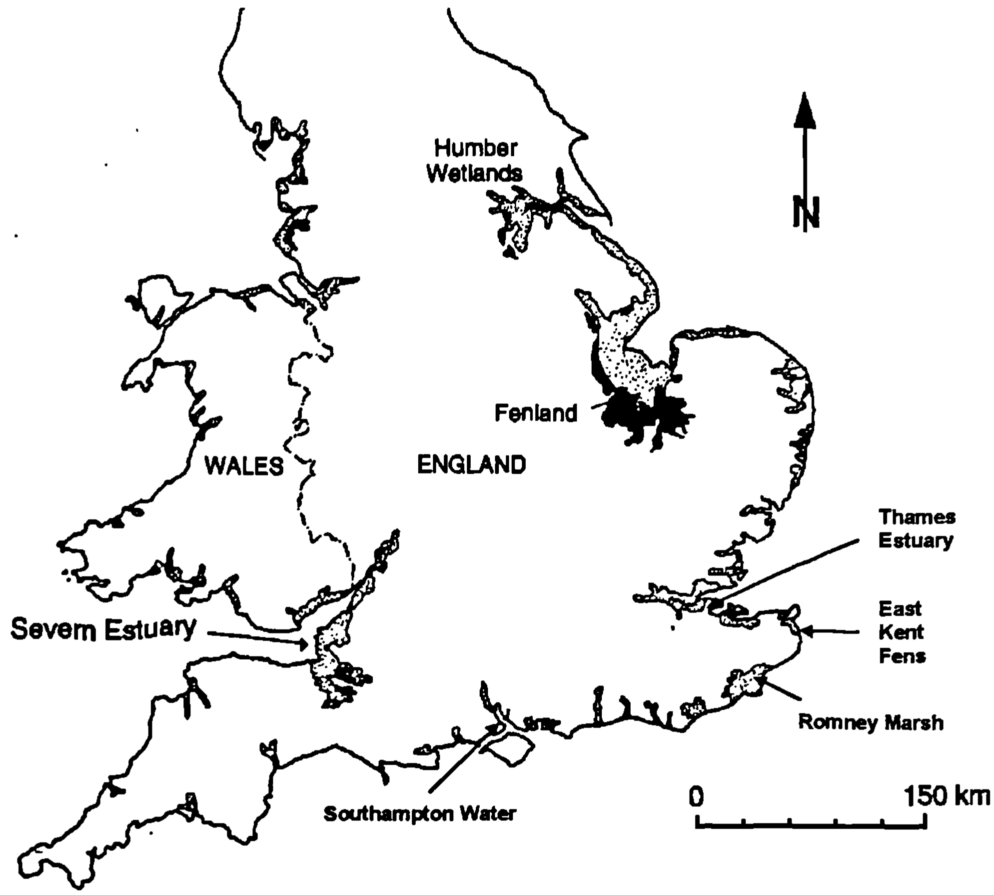



Figure 98. Location map of areas used as regional comparisons for sea level tendency, adapted from Bell et al. (2001)

A small palaeovalley in the east Kent Fens north of Deal and south of the Isle of Thanet was examined (Long 1991, 1992 and see Figure 98) with the construction of a tendency model with three phase of negative and two positive tendencies of movement. It begins with a peat formation from 7100-6300 calendar years BP replaced by relatively short phase of marine sedimentation until 5900 calendar years BP. A second peat is equated to the second negative tendency and subsequent positive tendency. Rising water tables and inundation are equated to this second positive tendency of long duration, to 3600 calendar years BP when peat began forming again. There is no date for the end of this last phase. There are some similarities between this model and the pattern shown in the Thames (see Figure 99). The initial pattern is dissimilar with a positive tendency in the Thames, but the negative tendencies are broadly comparable with Long's first negative tendency, beginning at broadly the same time as in the Thames, but being interspersed with a single clear positive tendency. The second period of peat formation in Kent occurs whilst the main phase of wetland expansion is still under way in the Thames. The subsequent submergence of the peats in both the Thames and Kent is also roughly contemporary, indicating, not unexpectedly that similar controlling mechanisms are at work in both these areas.

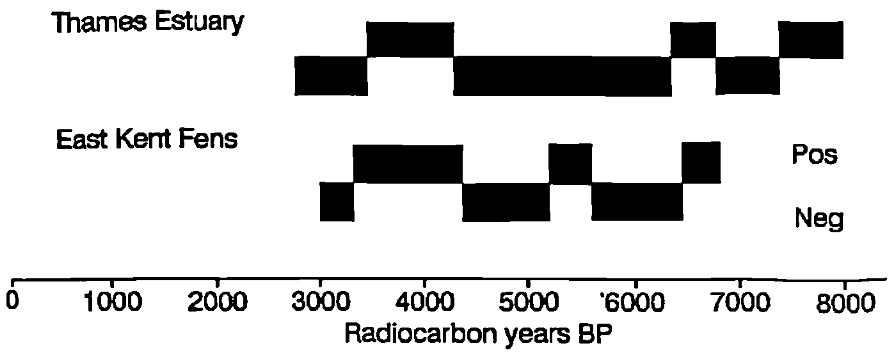



Figure 99. Tendency diagram comparing the east Kent Fens and the Thames, from Long (1991)

Romney Marsh has also been extensively examined, both archaeologically and geomorphologically (Eddison 1998; Waller et al. 1999). Recently, it has been the subject of a direct comparison with the Thames (Long 2001), which has demonstrated similarities in several aspects of the marsh and estuary development. This is most apparent in an initial period of rising RSL, followed by a wetland expansion between *c.* 5000-2500 cal BC and subsequent reduction, leading Long to attribute a regional forcing mechanism behind this pattern shown in both locations and indeed in Southampton Water (Long et al. 2000) and Holland (Denys 1999).

Southampton Water (see Figure 98) has been examined by Long and Tooley (1995) and Long et al. (2000) and the stratigraphic sequence follows a tripartite sequence proposed in 2000 for phases of estuary evolution in southern England also demonstrated in the Thames and the Severn. The first phase in Southampton Water is thought to begin *c.* 6000 cal BC until the peats advanced from *c.* 4350 cal BC. This phase lasted until *c.* 2550 cal BC when the peats began to be inundated by the contemporary transgression event. The model holds certain similarities with the Thames, although the period of peat formation in Southampton Water is rather short lived by comparison. The comparison of Southampton Water, the Severn and the Thames led to a composite sequence being proposed (see Figure 100).

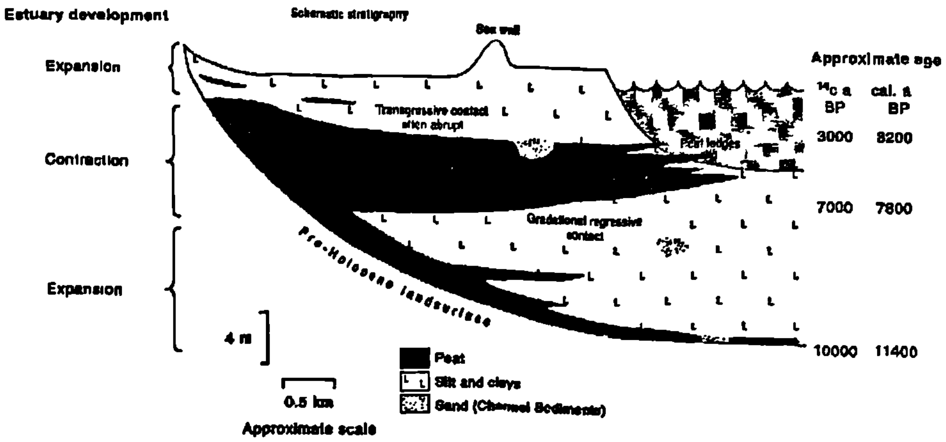



Figure 100. Simplified stratigraphic section of estuarine sequences from southern England, from Long et al. (2000)

Bell's extensive work in the Severn estuary (see Figure 98) has included an examination of tendency (2000), based on the excavations at Goldcliff (i.e. Bell 1993, 1995). The combined information from across Goldcliff has enabled Bell to produce a tendency bar (see Figure 101) demonstrating an initially complex picture, with a series of negative and positive tendencies of movement in the period 6000-4000 cal BC. However, this period seems to be generally one of positive tendency with two periods of a few hundred years each of organic formation. There is then, at 4000 cal BC a significant period of organic formation continuing to *c.* 1400 cal BC, when another phase of positive tendency replaces it, continuing mainly uninterrupted to the end of the sequence, at approximately 1 BC. The sequence at Goldcliff of Mesolithic transgression, Neolithic-mid Bronze Age regression and subsequent transgression matches the general Thames sequence indicated both by this work and that of Long et al. (2001), which also considered the Severn. There are some differences in the fine detail of the timing, but the general pattern is similar and indicates that the events are more than locally representative and may reflect conditions around southern Britain.

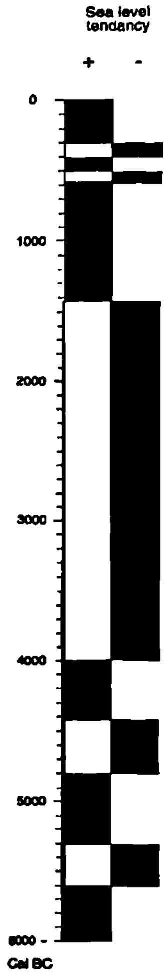



Figure 101. Tendency diagram for Goldcliff, from Bell (2000)

A comparison with the north of England can be made with the ongoing research in the Humber wetlands (Van de Noort and Ellis 2000; Van de Noort 2001), which has included examination of sea level tendency in the lower Aire valley (Kirby 1999, section 10.3). This has demonstrated a period of generally positive tendency of movement between *c.* 6000-600 cal BC, with a slight overlap to negative tendencies thought to start *c.* 1000 cal BC, continuing for approximately a millennium. The period of negative tendency is much shorter than that in the Thames (and the Severn), and does not begin until the period of time when the main peats in the Thames and the Severn are being inundated, indicating a significantly different pattern in northern Britain to that in the south. The work in the Humber has also used archaeological information to infer tendency; for instance, the location of the Brigg raft has been used as an indicator of estuarine extent in the late prehistoric (Kirby 1999, 324; Smith et al. 1981).

Earlier work on the Humber (Long, Innes et al. 1998) examined the record of RSL change, establishing a period of positive sea level tendency between *c.* 1400-500 cal BC, followed by a negative tendency for which there is evidence up to the Roman period (see Figure 102). This correlates with the later part of the sequence established by Kirby (1999). Long, Innes et al. (1998) indicate possible anthropogenic reasons for organic accumulation at this date, associated with woodland clearance and associated run-off leading to valley infilling and increased waterlogging, something which reflects well with increasing sedentism noted in the Bronze Age record across much of England.

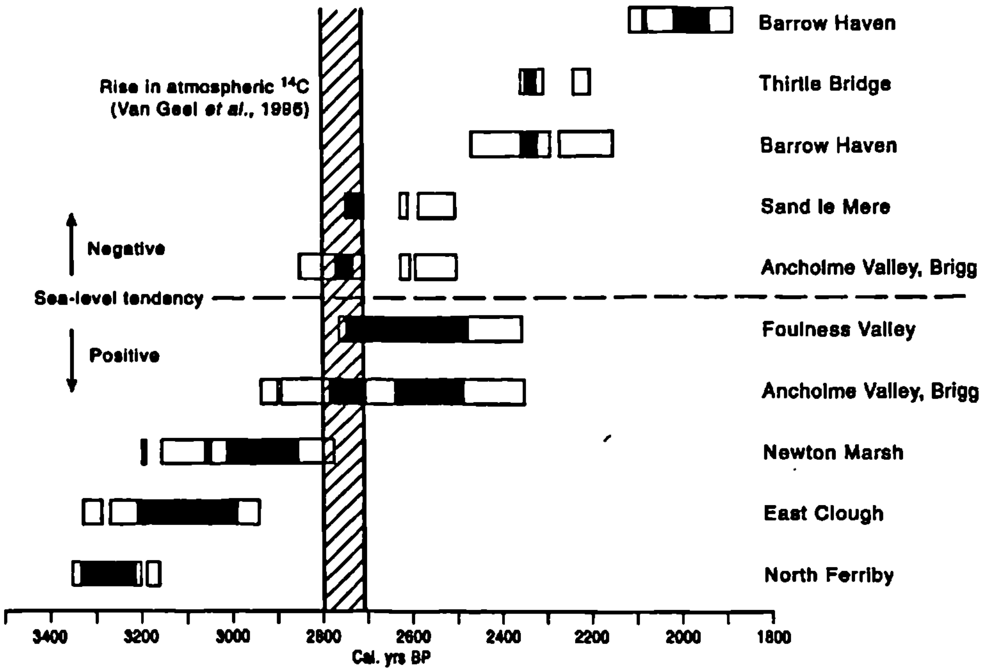



Figure 102. Tendency graph for the Humber during the period *c.* 1550 cal BC to AD150, from Long, Innes et al. (1998)

| | Longest span $^{14}C$ years BP | Altitude (long span) m. OD | Shortest span $^{14}C$ years BP | Altitude (short span) m. OD | Period of inception $^{14}C$ years BP | Long duration $^{14}C$ years BP | Short duration $^{14}C$ years BP |
|---|---|---|---|---|---|---|---|
| *This study* | | | | | | | |
| I positive tendency | >5010 -5010 | ? -2.55m | >5950-5950 | ? -4.35m | - | - | - |
| II negative tendency | >5950-2210 | -4.35-0.95m | 5010-3240 | -2.55-1.7m | 940 | >3740 | 1770 |
| III positive tendency | 3240-750 | -1.7-+0.76m | 2210-750- | -0.95-+0.76m | 1030 | 2490 | 1460 |
| *Long et al. (2001)* | | | | | | | |
| Initial transgression | 10,000-7000 | | | | | | |
| Regression | 7000-3000 | | | | | | |
| Second transgression | 3000-0 | | | | | | |
| *Devoy (1979)* | | | | | | | |
| Tilbury I | 8170-7380 | -13.4-13.23 | 8170-7380 | -13.4-13.23 | - | 890 | 890 |
| Thames I | 7380-7050 | -13.23-10.38 | 7380-7140 | -13.23-10.64 | - | 330 | 240 |
| Tilbury II | 7140-6575 | -10.64-10.1 | 6450-6680 | -8.45-8.62 | 790 | 575 | -230 |
| Thames II | 6680-4930 | -8.62-2.99 | 6575-6200 | -10.1-6.42 | 105 | 1750 | 375 |
| Tilbury III | 6200-3850 | -6.42-5.21 | 4930-4195 | -2.99-1.96 | 1270 | 2450 | 745 |
| Thames III | 4195-2836 | 1.96-2.73 | 3850-3240 | -5.21-2.0 | 345 | 1359 | 610 |
| Tilbury IV | 3240-2850 | -2.0-0.89 | 2836-2850 | -2.73-0.89 | 416 | 390 | -14 |

Table 27. Details of tendencies of movement for study sites (this volume), Devoy (1980) and Long et al. (2000)

## Summary

There is reasonable evidence from the Section II sites to show a tripartite pattern of sea level tendency with an initial Early Holocene phase of positive tendency of movement, shown on almost every site analyzed with varying levels of marine contact. This is replaced (earliest upstream) by a negative tendency of sea level movement over a period of 940 radiocarbon years between 5950-5010 radiocarbon years BP (Mesolithic/Neolithic transition). This takes the form of an extensive regressive overlap and the formation of a wood peat that is gradually replaced by fen peat, lasting for between 3740 to 1770 radiocarbon years. It is replaced by sediments indicating a further period of positive sea level movement (manifested first downstream then at upstream sites) over 1030 radiocarbon years, between 3240-2220 radiocarbon years BP (Middle Bronze Age to Late Iron Age). This phase of sea level movement is considered to have carried on to the present day, but cannot be detected in the sedimentary record as all sites are now behind river defences and/or have been built upon. The pattern is reflected elsewhere in the inner Thames estuary, notably in the North Woolwich/Beckton/Barking area, and indeed as far upstream as Southwark and Westminster. It does not immediately match the classic 'Tilbury' model, but there are distinct similarities with the more upstream of Devoys sites, such as Dartford and Church Manor Way.

In addition to the intra-estuary consistency for a pattern of positive-negative-positive, there are strong similarities displayed away from the Thames. This is most clearly shown in the Severn estuary (Bell 2000), but also at Southampton Water (Long et al. 2000), the east Kent fens (Long 1992) and Romney Marsh (Long 2001). The pattern from the east coast is different; with a more complex pattern shown in the Fenland (Shennan 1982) and a different pattern altogether in the Aire valley (Kirby 1999). Long has indicated that the similarities seen in the Thames, Severn, Southampton Water and Romney Marsh argue strongly for the same forcing mechanisms underlying the development in all these areas. The differences further north on the east coast suggest that the factors controlling sedimentation are not the same as those further south and west and may well be associated with isostatic processes.

## 11.2 Age-altitude

### Introduction

This section contains a discussion of RSL change using sea level index points obtained from the stratigraphic element of this research. The calculations used in litho-, bio- and chronostratigraphy to index points have been discussed in Chapter 3, above, and details may be found in Appendix 8, Tables 94-98. The dataset include those generated by the present study and those from the University of Durham sea level database, with the addition of one point from Tilbury (1 on Figure 103), excluded from the Durham database, but used by Long (1991). Limiting data, (i.e. those which have no direct altitudinal relationship to a former sea level) have not been used as these are considered to be of little assistance and can overly confuse diagrams. All points have been reduced to MSL, to ensure comparability between sites.

In addition to the construction of index points using the modern reference water levels required in the calculations described in Chapter 3, each point used has also been calculated using MHWST and HAT calculated for dates over the last 2000 years. The problem of calculating changes in tidal range is a fundamental one (see Chapter 2) and often leads researchers to make the assumption that there has been no change in tidal range over the Holocene, i.e. Kirby (1999). This is perhaps not so much an assumption than a tacit acknowledgement of the difficulty of establishing the magnitude of change. Unfortunately, it has not been possible to calculate tidal range for the prehistoric period in the Thames estuary, but it is hoped that the historic period ranges that have been constructed are at least a step in the right direction. The way these have been calculated is discussed in Chapter 3 and further detail may be found in Chapter 11.3 below. Figures 104-109 show the age altitude graphs, based on data presented in Appendix 8. The chronology for each point is expressed at the maximum confidence intercept (95% confidence) of the radiocarbon ranges. The basal peat dates have been distinguished in the graphs as these values are likely to be less affected by sediment compaction and therefore more accurate than non-basal points (see Shennan 1994). Unfortunately there are few of these points. In the main, the index points are calculated from transgressive overlaps with biostratigraphy showing a positive tendency of sea level movement.

| No | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Silvertown | 4050 | 8035 |
| 2 | Masthouse Terrace | 3750 | 7850 |
| 3 | Tilbury | 6466 | 7570 |
| 4 | Gallions Reach | 4490 | 7985 |
| 5 | North Woolwich | 4345 | 7985 |
| 6 | Suffolk House | 3271 | 8077 |
| 7 | Storeys Gate | 2990 | 7960 |
| 8 | Union Street | 3178 | 8001 |
| 9 | Broadness | 6057 | 7664 |
| 10 | Stone Marsh | 5702 | 7594 |
| 11 | Westminster | 3022 | 7962 |
| 12 | Bramcote Grove | 3515 | 7805 |
| 13 | Wennington Marsh | 5425 | 8025 |
| 14 | Crossness | 4815 | 8050 |
| 15 | West Thurrock | 5883 | 7700 |
| 16 | North Southwark | 3250 | 7950 |
| 17 | Littlebrook | 5622 | 7584 |
| 18 | St Stephens East | 3000 | 7800 |
| 19 | Voyagers quay | 4730 | 8130 |
| 20 | Joan street | 3250 | 8000 |

Table 28. Sites shown on Figure 103

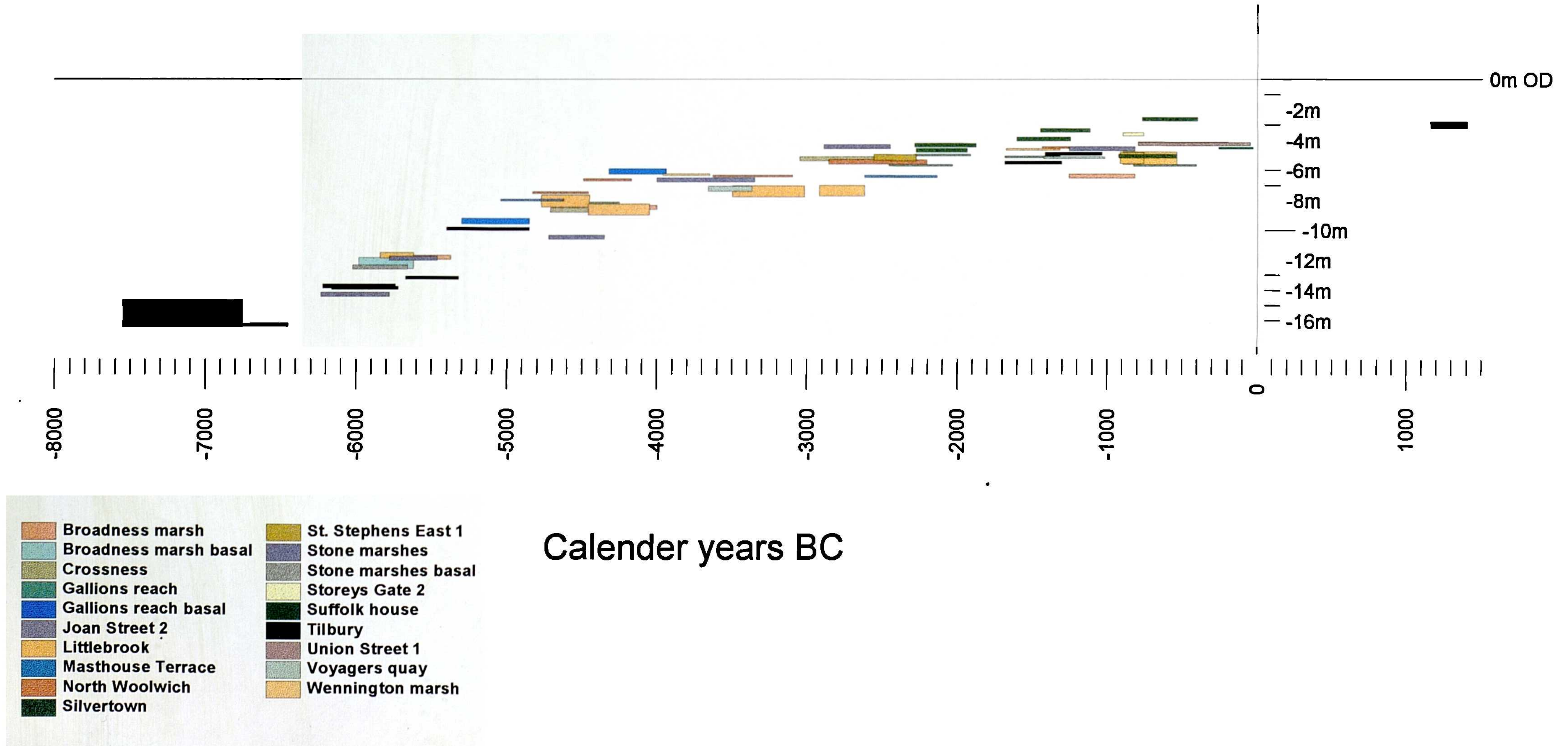



Figure 104. Graph showing sea level index points from theThames estuary, reduced to MSL, calculated using MHWST and HAT values for 2001

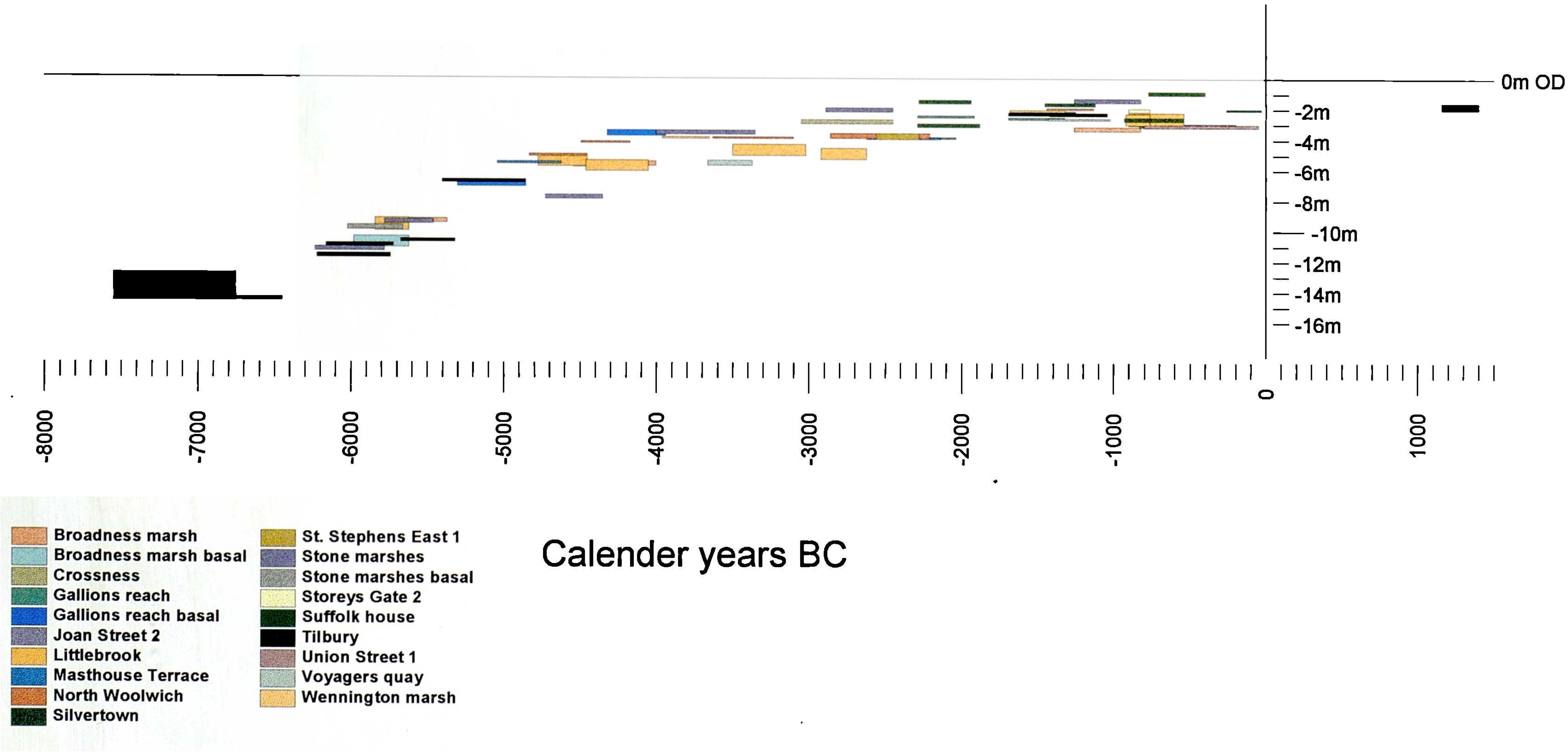



Figure 105. Graph showing sea level index points from theThames estuary, reduced to MSL, calculated using MHWST and HAT values for AD50

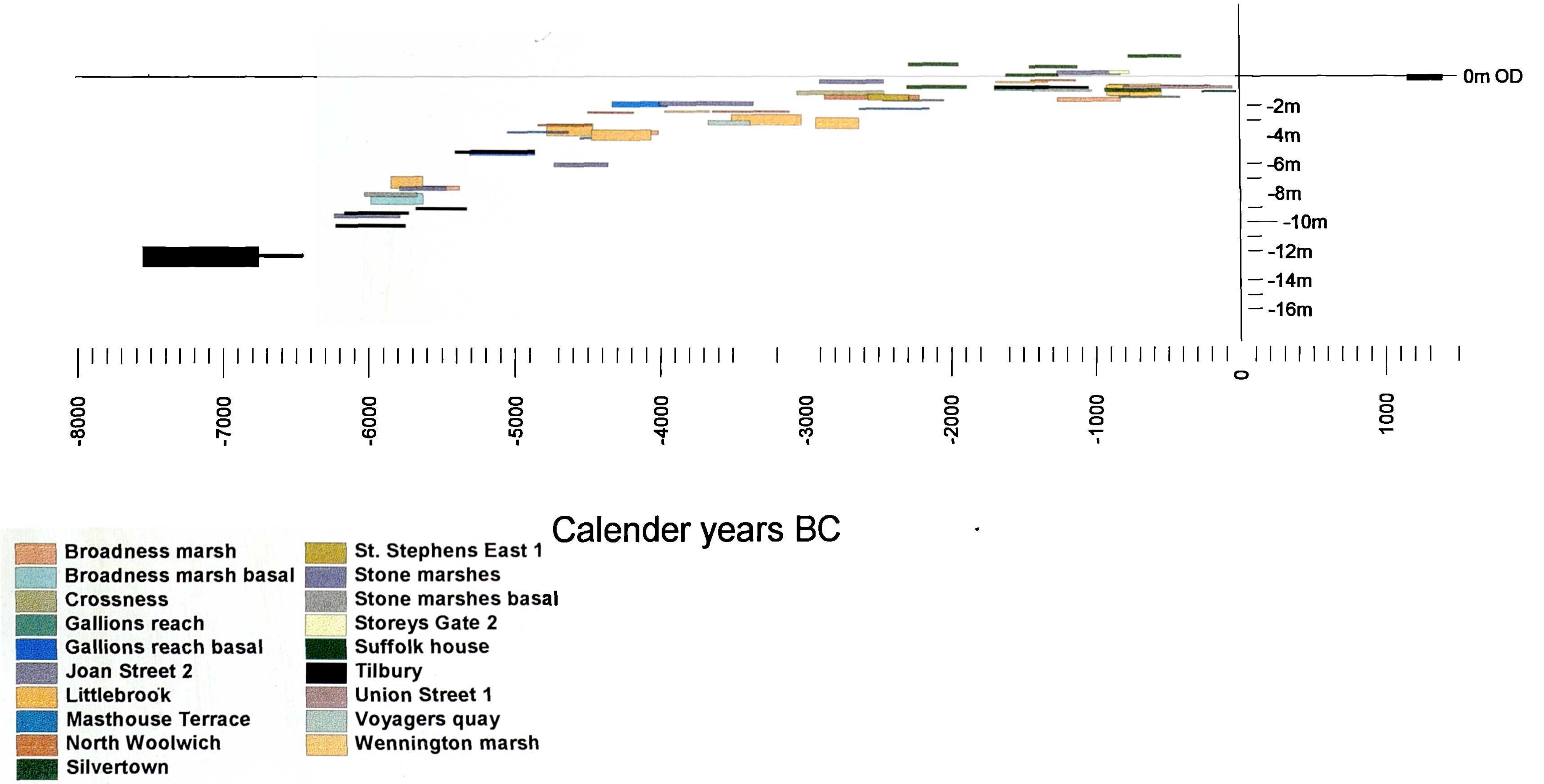



Figure 106. Graph showing sea level index points from theThames estuary, reduced to MSL, calculated using MHWST and HAT values for AD 300

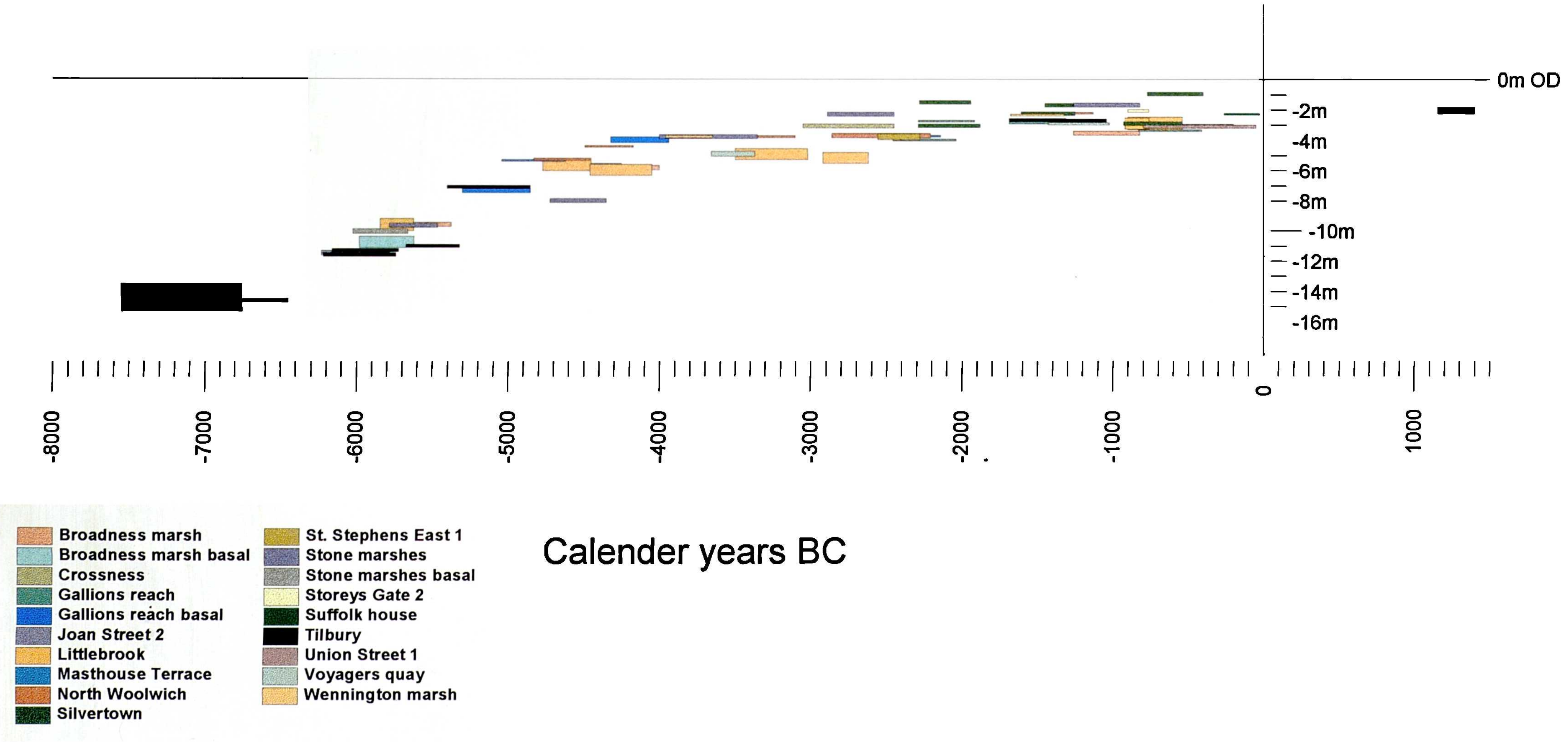



Figure 107. Graph showing sea level index points from theThames estuary, reduced to MSL, calculated using MHWST and HAT values for AD 100(

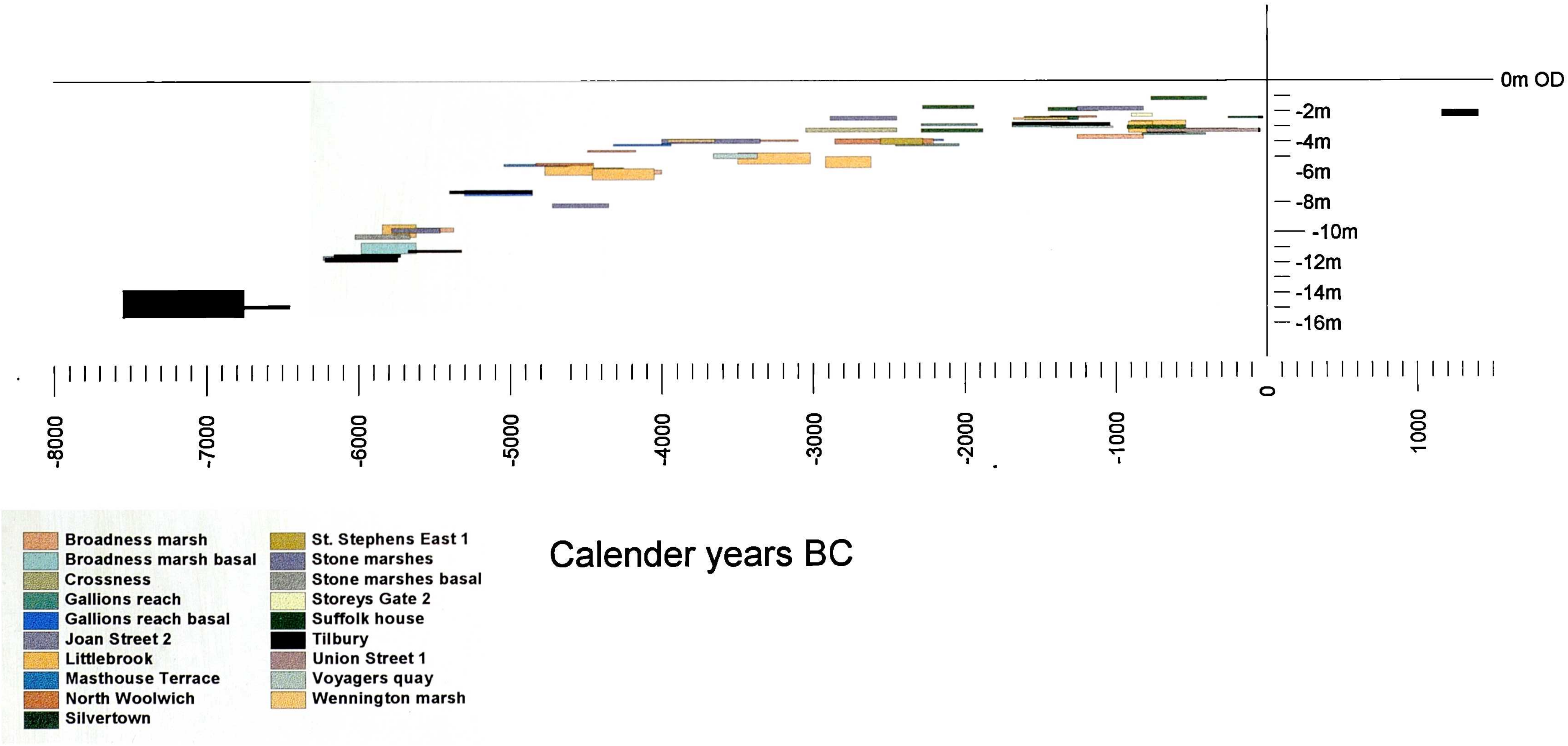



Figure 108. Graph showing sea level index points from theThames estuary, reduced to MSL, calculated using MHWST and HAT values for AD1400

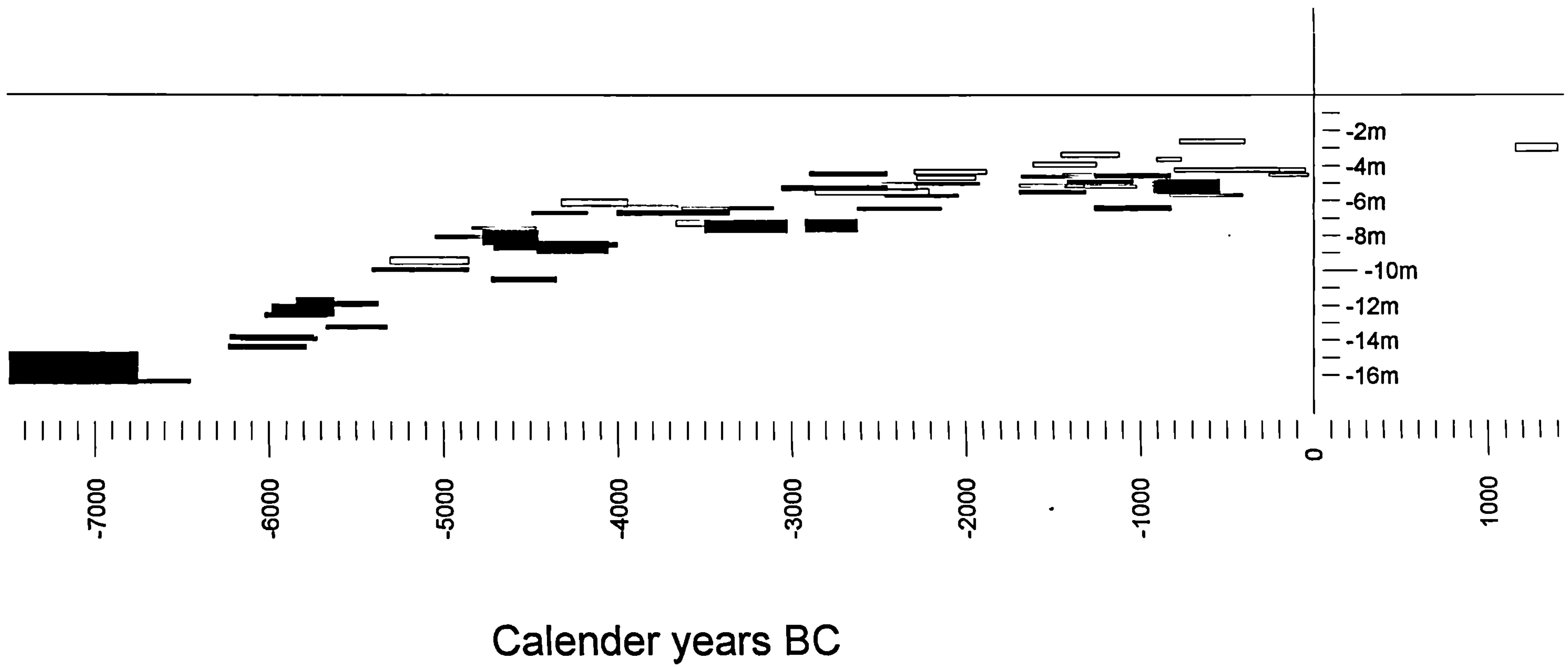



Figure 109. Graph distinguishing new sea level index points (white) from old (Shennan 1989, black), calculated using modern MHWST and HAT

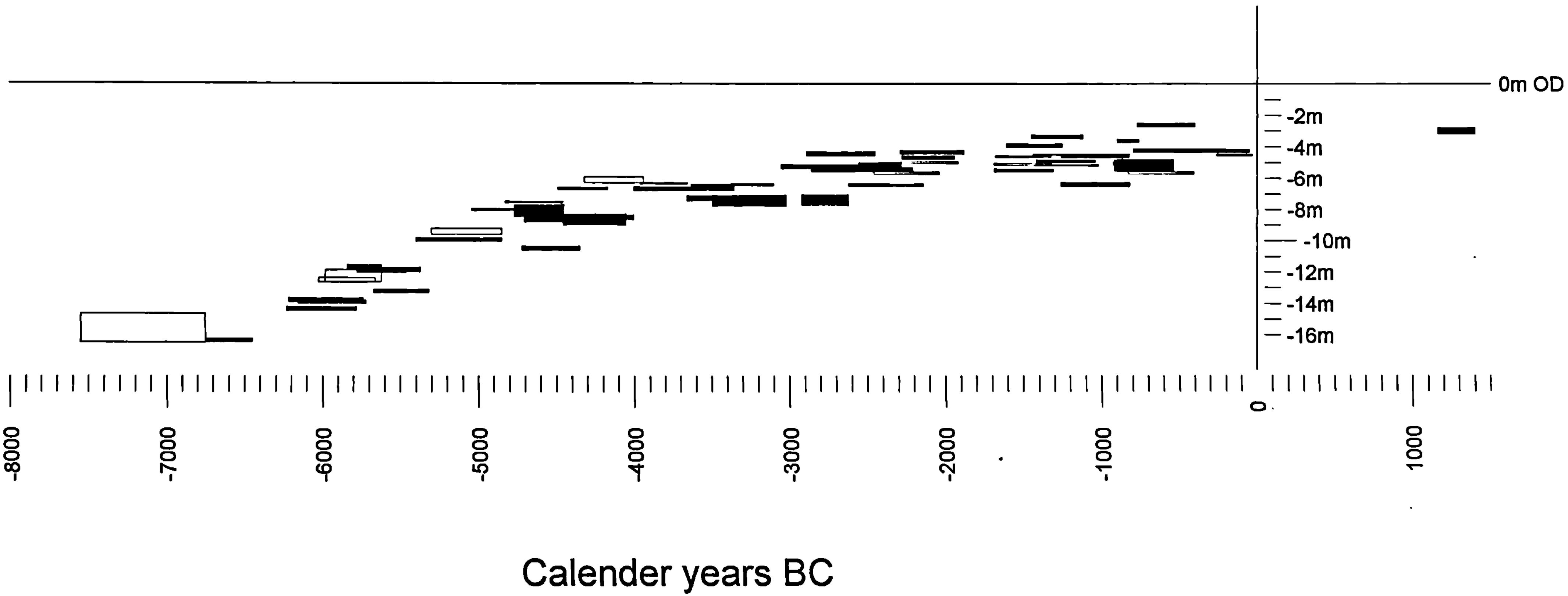



Figure 110. Graph distinguishing basal sea level index points (white) from non basal points (black),calculated using modern MHWST and HAT

## Age-altitude graphs

Figure 104 shows all sea level index points calculated using modern MHWST and HAT values. General things to note are the consistent upward trend in RSL with a pronounced slowing of the overall rate at around 4000 cal BC. This is matched by the tendency analysis in Chapter 11.1, which shows an increase in negative tendency index points from this time onwards. There is considerable 'scatter' within the graph, but this may be a factor of differential compaction rather than evidence for small-scale oscillations in sea level. There appears to be a general trend that the more upstream/westerly sites at Silvertown and Masthouse Terrace (1 and 2 on Figure 103) plot higher than those downstream. Furthermore, the points from Tilbury (3 on Figure 103) plot lower than points of similar date. This was shown in the original model (Devoy 1979) and has been discussed since (Long 1991, 1995; Haggart 1995), but is confirmed here by comparison with the new data, where points from Gallions Reach, North Woolwich (4-5 on Figure 103), Silvertown and Masthouse Terrace all plot higher. An anomaly with this is that the points from Silvertown generally plot higher than those from upstream, i.e. Suffolk House, Storeys Gate and Union Street (6-8 on Figure 103).

### *Basal points*

The basal dates (see Figure 110) indicate increasing waterlogging on the gravel terrace dating from *c.* 7000 cal BC at *c.* -15.5m from Tilbury. This index point gives an early indication of rising watertables from within the study area with the formation of a wood peat (Devoy 1979), and is a thousand years earlier than any of the other basal dates from the estuary. The next in sequence come from Broadness and Stone Marsh (9-10 on Figure 103), at an altitude of *c.* -12.4 in both cases. Devoy (1979) classes these as Tilbury II freshwater wood/alder carr peats with the possibility of nearby salt marsh at Stone Marsh. Two new basal dates have been obtained on organic muds, both from Gallions Reach, dating to *c.* 5000 cal BC (-9.4m OD) and *c.* 4000 cal BC (- 6m OD). The second of these formed over a gravel high in the south of the site, giving some indication of the rate of organic formation in the area. The earlier deposit was an organic mud, with some diatom evidence for marine conditions. These form the total of basal index points from the Tilbury to Westminster (11 on Figure 103) stretch of the estuary. It should be noted however, that there is earlier evidence of organic formation, from both Masthouse

Terrace and Silvertown, dating to the Late Devensian. These deposits are thought to have formed in relict channels, but are evidence for earlier organic formation than has been previously thought for the estuary, along with deposits from Bramcote Grove (Thomas and Rackham 1996, 12 on Figure 103). It seems unusual that Devoy did not recover any similarly dated deposits and it is perhaps a phenomenon only to be found in this reach of the river, associated with the Isle of Dogs meander. However, it is also possible that thin organic units on the gravel may not have been noted in the commercial logs that form a large part of his dataset.

Chronologically, the second group of index points comes from the top of the basal peats. As has been shown, there are relatively few organic deposits resting directly on the Devensian gravel. Generally, inorganic sediment rests upon the gravel, but this could not be dated. The dates from the transgressive overlap at the surface of the basal peats that do exist give a good date for early marine conditions in the estuary, although marine conditions certainly reached Gallions Reach during basal organic formation.

The earliest available point comes from Tilbury and dates to *c.* 6800 cal BC, where the diatom assemblage indicates brackish water. Further upstream, the basal peat at Broadness Marsh is sealed at *c.* 5500 cal BC (-11.8m) whilst that at Stone Marsh is also inundated at a very similar date, but *c.* 0.6m lower. The pollen suggests freshwater conditions at this point. The organic muds at Gallions Reach develop into true peats, with no actual transgressive overlap until significantly later.

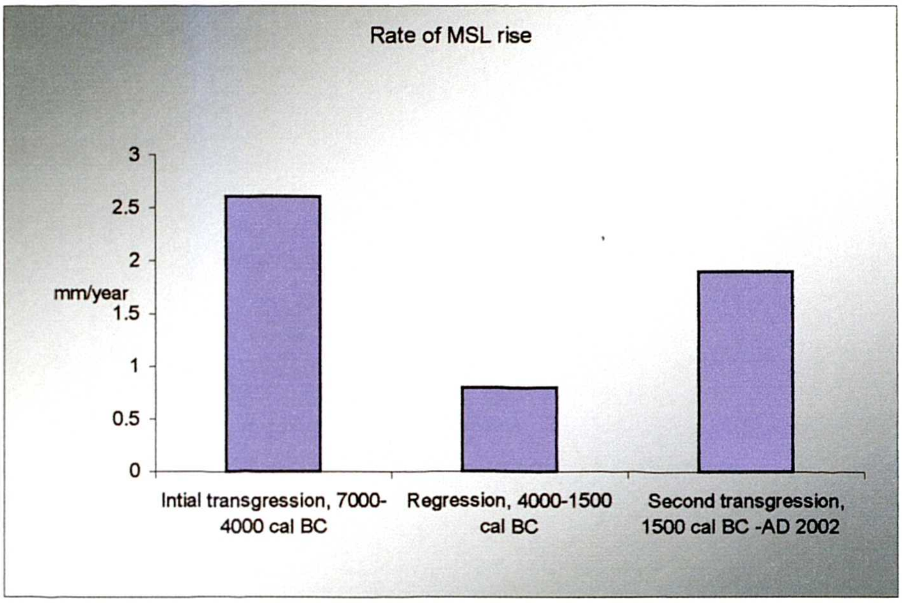
During the period of basal peat formation and the initial positive marine tendency, between 7000-4000 cal BC, the graphs indicate that MSL rose by *c.* 8m, or *c.* 2.6mm/year for this period (See Figure 111), indicating rapidly rising waters. Comparison with Devoy (1979) is difficult, as he does not consider this period independently, and indeed records a RSL drop at *c.* 6000 cal BC. He records a rate of rise of *c.* 5mm/year for the period 5500-4500 cal BC; still double that suggested by the new graphs; however, the work of Jelgersma (1961) suggests 3.6mm/year for the Dutch coast of this date.

A final point to be made regarding the basal points relates to sediment compaction. By comparing the altitude of basal points with those of similar date, it is possible to examine compaction. The older basal points plot above points of the same date range elsewhere by up to three metres. The younger basal points tend to be incorporated into the middle of the general scatter, apparently indicating some compaction elsewhere, but nowhere near as significant as associated with the older dates. This is obviously related to the weight of overburden, differentially compacting the lowest deposits, and suggests that compaction is much less of a problem with the younger deposits.

### *Wetland expansion*

During the discussion of tendency in Chapter 11.1, it has been shown that there is a major period of wetland expansion in the estuary dating from *c.* 4000 cal BC. This is dated by the regressive overlap in several site sequences. The outer estuary sites do not generally follow the same pattern. However, the Tilbury III peat does start forming in several places at roughly this date with a regressive contact of *c.* 4200 cal BC at Broadness and *c.* 3600 cal BC at Stone Marsh, at depths of -8.4 and -6.6m OD, respectively. However, the chronology shows that the peat forms earlier out in the estuary (Tilbury) and latest further up the estuary (Stone Marsh). This is in direct contrast with the pattern between Masthouse Terrace and Wennington (13 on Figure 103 and see Figure 111). Furthermore, it is contrary to expectations of wetland development within this type of system, where coastal advance is more likely to begin further from the sea. Although it is possible that lag time in peat formation might be expected in locations perpendicular to the estuary and therefore the marine interface compared with those adjacent to it, in this case the pattern at Tilbury and Stone Marsh is unlikely to be explained by this possibility as Stone Marsh is currently very close to the Thames.

Marine conditions are seen in the diatom record during the period of wetland expansion, and it is considered that the slow down in the rate of rise shown in Figure 104 is just that, a slowing, but not an actual drop, in RSL rise. The three points from North Woolwich between 5000 and 3000 cal BC show this trend clearly. The reduction in the rate begins at *c.* 4000 cal BC and lasted for up to 3500 years, when the peat formation ceased at Suffolk House, overlain by the gravel foreshore. This occurred relatively late, and it can be seen on Figure 104 that there is a cluster of points marking the transgressive overlap from c. 1600 cal BC. The graphs indicate that during the period 4000-1500 cal BC, MSL rose by *c.* 2m, or 0.8mm/year. Superficially, this corresponds well with the rate of 0.75mm/year predicted by Shennan and Horton (2002) for the Thames for the period 2000 cal BC to present and suggests that their rate of rise could be extended back to *c.* 4000 cal BC. However, Shennan and Horton compensated for compaction, allowing 50% compaction. If this is applied to the new data, then the rate for the period of wetland expansion is lower than that applied by Shennan and Horton, which is to be expected for this period of estuary contraction.




**Based on calculations using modern reference water levels and not correcting for compaction**

Figure 111. Bar chart showing estimated rates of MSL rise,

### *Second transgression*

The transgressive overlaps from the peat from *c.*1500 cal BC record the second phase of estuary expansion. These points are oldest downstream at Wennington and Gallions Reach. Here, transgressive contacts occur at -4.6 and -5.0m OD respectively from *c.* 1500 cal BC. Two transgressive contact dates from the Devoy model occur a millennium earlier at Crossness (14 on Figure 103) and Stone Marsh at -5.2 and -4.2m OD respectively, again showing problems of relative depth and position within the estuary. This is because Stone Marsh is nearer the sea and would therefore be expected to be subject to the transgression earlier. It is unusual that the event should occur at the same depths but separated in time by a millennium. This could potentially be explained by increased compaction upstream, occurring against a background of relatively slow RSL rise.

The majority of points from *c.* 2000 cal BC come from transgressive overlaps showing an increased rate of RSL rise with the transgression occurring later and altitudinally higher in the upstream zone. As has been noted above, the Silvertown points plot higher than those in the City reaches and at Westminster. Silvertown has been relatively undeveloped, whereas the City has been intensively built upon since the Roman period and the anomaly could be a result of greater compaction upstream relative to Silvertown. Another possibility is that of increased tidal friction around the Isle of Dogs and up into the City, where the palaeotopography takes the form of islands, tidal creeks and marsh on the south bank. This could have led to tidal dampening and an up-estuary reduction in tidal amplitude, possibly accounting (in part at least) for the relatively higher MSL altitudes recorded at Silvertown.

Taking modern MSL as OD, the calculated rate of MSL rise over the period 1500 cal BC to AD 2002 is *c.* 1.9mm/year; over double that of the rate during the period of wetland expansion, but less than that estimated for the initial Holocene transgression. The relative rates across these periods are unexceptional as the second transgression is unlikely to match the initial one, owing to the increase in global ocean volume experienced in the Early Holocene. However, Shennan and Horton (2002) have calculated a net rise in MSL of 0.74mm/year, for roughly the same period. When the correction for compaction is taken into account, the figures are closer with a value of 0.95mm/year for the new data, or 1.48mm/year for Shennan and Horton if the correction is removed.

### *Historic tidal range*

The MSL graphs plotted with points calculated using MHWST and HAT from the historic period (Figures 105-108) show a clear altitudinal differential from Figure 104 with some index points being raised by up to 5m from the calculated MSL altitudes shown on Figure 104 (Tables 15 and 16, Chapter 3). This greatest differential comes by using the AD300 values, with MSL shown at OD in the medieval period and above OD in the Late

Bronze Age. This accords reasonably well with what is known of the archaeology of these periods, for instance when the Southwark fields were submerged, and if true, indicates that MSL dropped at some point subsequent to the Bronze Age. The other historic period graphs were plotted to indicate the variation to be obtained through attempting this method, however, they show less differential than that using the AD300 values - therefore, this diagram is considered to be the more accurate graph.

There is a particularly clear trend in the archaeological record for a drop of *c.* 1.5m in MHWST and HAT for the Roman period. Unfortunately, this is a period for which there are no stratigraphical sea level index points with which to test this. All the evidence comes from the waterfront archaeology discussed below in Chapter 11.3. This leaves the problem of how to account for this apparent drop at this date. Devoy (1979) recorded a small regression (Tilbury V) at this period, but did not suggest a direct cause for it. Limited data from outside the Thames lends some credence to historic period fluctuations in MSL. In Poole Harbour Edwards (2001) has identified a possible drop in MSL between the end of the Roman and the mid Saxon period. This does not overlap with the Thames, but indicates that there are periods where MSL does oscillate.

Further evidence comes from the Belgian coastal plain where there is some evidence for a regression during the Roman period (Baeteman 1983; Ervynck et al. 1999), previously thought to have taken place throughout the entire Roman period. A further parallel is a negative tendency of sea level movement in the Fenland (Waller 1994a, 81) identified between AD150-300. Although the start date is earlier in the Thames, the end date for the Fens matches very closely and lends credence to the suggestion of coastline advance if not necessarily a drop in RSL. There is additional circumstantial evidence of a drop in RSL in the Roman period, which comes from evidence for a Late Roman transgression. This has been identified in the Severn (Rippon 1997; Locock and Walker 1998), Romney Marsh (Long, Waller et al. 1998; Rippon 2000, 138) and the outer Thames and Crouch (Wilkinson and Murphy 1995, 220-221).

There is only one sea level index point from the post-Roman period. This comes from Silvertown and dates to the medieval period, *c.* 1100-1400. It is difficult to say anything about one date, however, when it is compared with the Late Iron Age points, there is an apparent rise in MSL shown. However, when compared with some of the previous points from Silvertown, it can be seen that there is no net altitudinal rise, and indicates an anomaly here. The earlier Silvertown points plot relatively higher than those from further upstream and it is possible that either Silvertown has not been similarly compacted, or possibly that variation in tidal elevation around the Isle of Dogs meander and into the City led to deposits forming at slightly higher altitudes at Silvertown. Nevertheless, when the medieval point is viewed against earlier ones from elsewhere, a rise is shown, and it seems likely that it represents a real trend, especially when compared with the archaeological data for the period (see 11.3 below), with MSL at approximately OD. This contrasts with a figure of *c.* -3m OD shown on Figure 104. It should be noted that the archaeology of the period shows the waterfront (thought to approximate to HAT) during the Early medieval period to be at *c.* +1.5m OD.

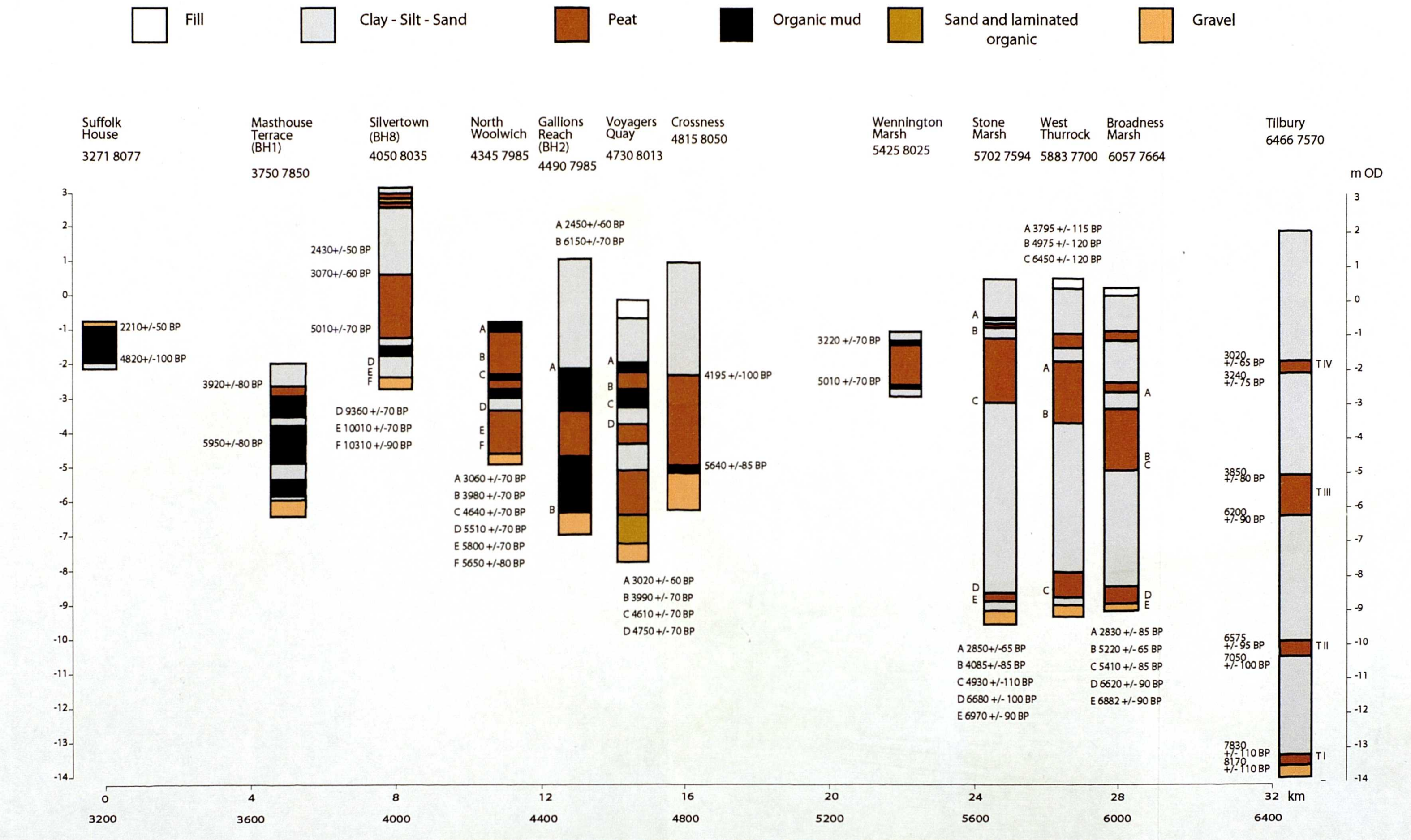



**Figure 112. Simplified stratigraphic cross-section through the inner and middle Thames estuary**

## Regional comparisons

Long (1991, 1992, 1995, 2001), Shennan (1989), Long et al. (2000) and Shennan and Horton (2002) have compared the Thames with other British estuaries. There are clear parallels when the simplest tripartite model of RSL change is viewed; rapid rise followed by a more gradual rise and then a second increase in the rate of RSL rise from *c.* 1500 cal BC. Unfortunately, the fine detail is too often absent for close comparison. This is particularly the case with the historic period and the Early Holocene where index points are generally unavailable. However, the pattern of sea level tendency in the Thames is readily matched in the Severn, Southampton Water (Long et al. 2000) and Romney Marsh (Long 2001). Comparison with the Fenland is more difficult, with less obvious matches of age/altitude and tendency (Shennan 1992, 1994). Nevertheless, the trend observed by Waller in the palaeoecological and palaeogeographical record (1994a) of systematically rising RSL with a period of coastal advance and dominance of positive tendencies from *c.* 4000 cal BC indicates reasonable affinity with the Thames.

## Discussion

This examination of the available age-altitude data from the Thames allows several issues to be discussed. The problems with the Devoy model will be discussed alongside Devoy's own suggested explanations (1979). The appropriateness of continuing to use Tilbury as a type-site will be discussed and finally, a new model for inner and mid estuary trends of sea level tendency and age/altitude change will be proposed.

### *Differential crustal movement*

The reasons cited by Devoy for the altitudinal offset between his inner and mid estuary curves were differential compaction, changing tidal amplitude but more particularly, downwarping. Differential downwarping has been discussed by several authors (Shennan 1987b; Long 1995) who found no evidence to support this suggestion. Long refuted the suggestion of differential crustal movement along the estuary by comparing the Thames data with that from the East Kent Fens (1992, 1995), which compared well with the inner Thames and therefore negating the idea of west-east subsidence. Indeed, Long (1995) indicated that compaction and to a lesser extent, changes in tidal range may have contributed to this appearance of crustal movement. Certainly there is no evidence on the geological map for the area (BGS sheet 271, Dartford) of any structural features (such as faults).

### *Differential compaction*

The potential for differential compaction within the estuary is high, owing to variables such as location and nature of the biogenic deposits. Devoy ruled compaction out, stating that this had not:

*'....caused major discrepancies or anomalies in the heights of the peat and clay sequences seen in the stratigraphy'* (Devoy 1979, 394).

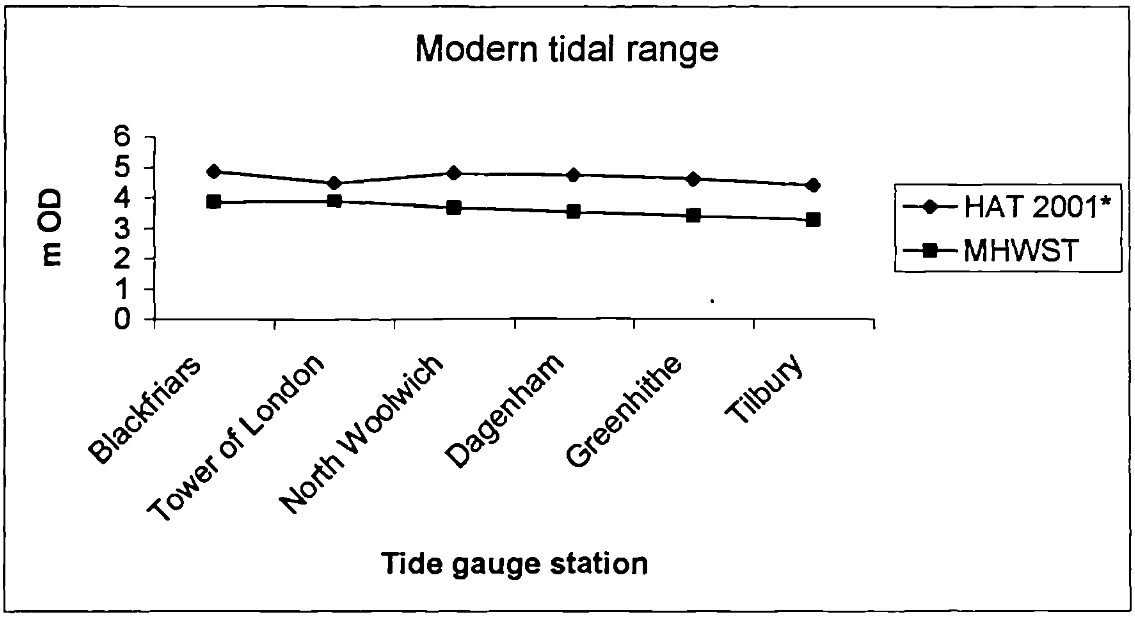
Yet, one of the bigger problems with the Devoy model is just that - peat formation at Tilbury occurring at different altitudes to elsewhere (see Figure 112 above), generally (but not consistently) lower than that observed at other sites. This might suggest increased compaction at Tilbury had more of a role than Devoy estimated. Furthermore, there is a possibility that the presence of the substantial unit Thames III has caused some of the apparent anomalies within the Tilbury sequence. This unit could have led to a greater compaction of the underlying Tilbury III than occurred at the other sites where Tilbury III is present, and where Thames III is less than a fifth of the thickness as at Tilbury, i.e. Broadness, Thurrock and Stone Marsh. There have also been questions over the Tilbury III/Thames III transgressive contact being too young relative to the non-Tilbury sites, however, if Tilbury III has been over-compacted relative to them, then this would no longer be anomalous.

The issues involved with the thickness of the Thames III deposit might also be used to explain the other major problem at Tilbury; that Tilbury IV is relatively old and high. It may be possible to answer this by invoking the same premise of differential compaction in relation to the other sites, but in reverse. Tilbury IV at Tilbury is likely to have formed on a firmly consolidated surface of a 2m thick Thames III, which had compacted the underlying Tilbury III. However, at the other sites, Tilbury IV formed on a much thinner Thames III, as little as 0.2m at Stone Marsh, which is unlikely to have had sufficient density to greatly compact the underlying Tilbury III. Possible support for this comes with the relative thickness of Tilbury III; 2m at Stone Marsh and *c.* 1.25m at Tilbury. It is unfortunate that the upper contact of Tilbury IV is only dated at Tilbury; it is to be expected that it would be submerged first and lower here relative to the other sites, but it would be useful to know by how much. By considering these issues, it appears that there are indeed significant problems caused by differential compaction.

### *Changing tidal amplitude*

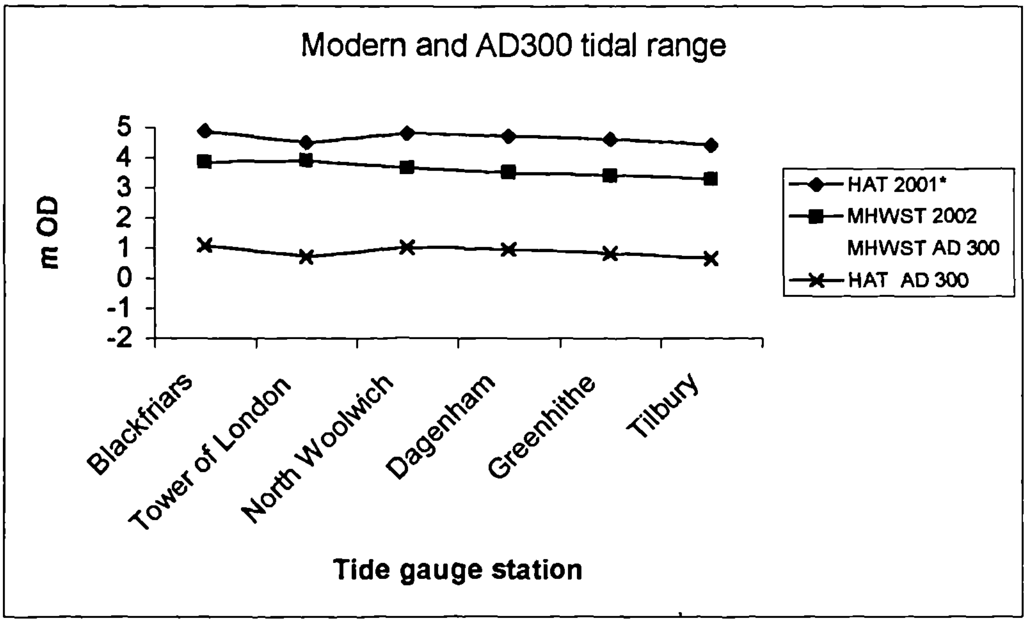
The second of Devoys suggestions of increased tidal amplitude up estuary is certainly a factor, however, it is difficult to know by how much. Devoy cites increasing tidal amplitude as a cause for the upstream deposits to form at a higher altitude. Figure 112 shows that there is limited increase from the downstream to upstream zones, however, it seems unlikely that this was ever enough to cause the discrepancies identified in the Tilbury model. Comparison of the modern with the AD300 values (Figure 113) indicates that there was a greater difference between HAT and MHWST, but it does not seem likely that this would have caused the altitudinal differential in Devoy's sea level curves. The change from estuary expansion to contraction at *c.* 4000 cal BC is likely to increased tidal amplitude at this period, but if there was such a change, it may have been negated when the wetlands were submerged during the subsequent transgression. Following on from this, there is no evidence in the historic period for significant increase in tidal range until the medieval period (Figure 113), resulting from embanking and the effect of London Bridge. By this time, the sequence at Tilbury was sealed, nor in an affected area. On the basis of these points, this explanation for the discrepancies does not seem likely.

More recently, calculations of sea level change using modeled Holocene tidal range (Shennan and Horton in press) have been calculated for several estuaries and revealed altitudinal variation of up to 2m. This is seen in the Fenlands, and compares relatively well with that calculated in this thesis for the Thames, of up to 5m. Furthermore, Shennan and Horton have calculated the rate of relative land subsidence/sea level rise since in the Thames since 2000 cal BC to be in the order of c. 0.74mm/year RSL rise. They have demonstrated that where previous tidal range is brought into the equation, this rate generally decreases. As yet, they have not corrected the sea level index points from the Thames for such change, but in the Fens, the predicted rate of RSL rise was halved. If the Thames is truly showing a greater change in tidal range variation than the Fens then potentially the calculated relative subsidence rate should also be halved here, to below 1.5m over the last 4000 years.



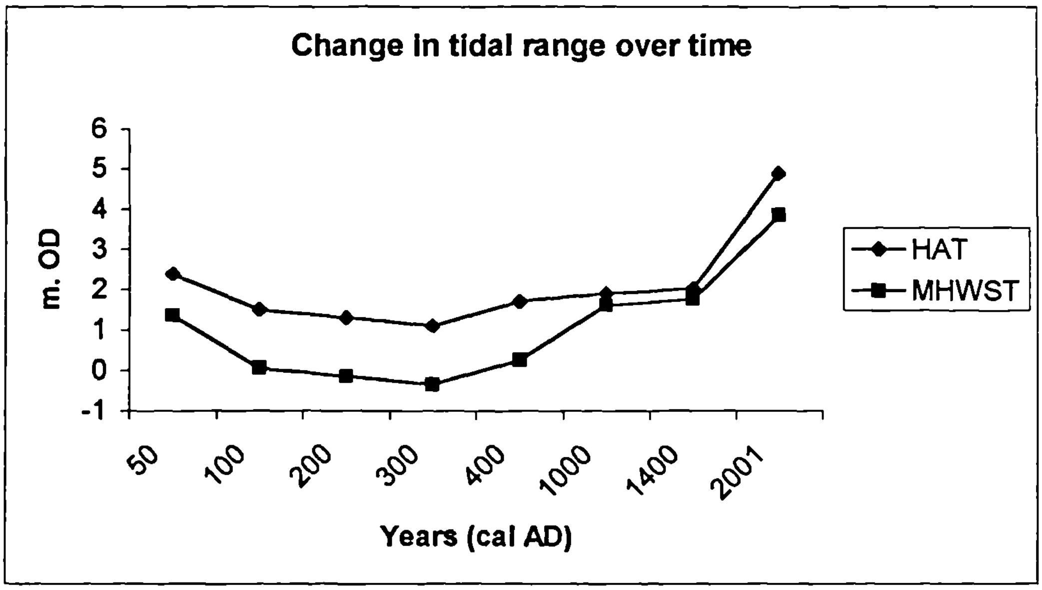

* calculated using all tide readings for 2001

a) modern tidal range




* calculated using all tide readings for 2001

b) distinguishing modem and AD300 values




c) Tidal range change throughout the historic period, calculated for Blackfriars

Figure 113. Graphs showing tidal variation within the estuary

### *RSL change in the Thames- summary*

It is clear that the new data discussed in this thesis do not accord absolutely with those published by Devoy (1979) and that it must be considered that the problems with the Devoy model discussed by other authors (Haggart 1995; Long 1995) will not easily be resolved. As yet, the best explanation for the difference between Devoy's two curves is associated with differential compaction within his stratigraphic model, rather than crustal or tidal issues. It is clear that until the problems are resolved, Tilbury's utility as a type-site for the estuary is null and void.

A new model is therefore proposed, incorporating both tendency and age-altitude information based on both extant data and new data gathered for this thesis. This is of a tripartite sequence of change.

*Phase I- Early Holocene transgression*

The actual onset of this is not accurately dated; organic sedimentation associated with the rising watertable is seen from *c.* 7000 cal BC and sealed by mineral sediment with evidence for estuarine waters. Mineral sediment is seen elsewhere before 6000 cal BC, again, containing evidence for estuarine conditions. It is suggested that the middle/inner estuary was subject to the transgression from at least as long ago as 6750 cal BC and was made manifest in both mineral and organic sequences with a calculated rate of RSL rise of 2.6mm/year.

*Phase II - Wetland expansion*

The estuary was subject to a slow down in the rate of RSL rise from *c.* 6000 cal BC, demonstrated in the widescale development of peat, in some places leading to the development of mature wood peat including the *Taxus* community. This took approximately a millennium to occur from upstream to downstream, between *c.* 4800-3800 cal BC. This appears to have occurred whilst RSL continued to rise, at approximately 0.8mm/year.

*Phase III - Second transgression*

The final phase reflects conditions from the transgressive overlap sealing the peat beds formed in phase II and takes the form of widespread estuarine mineral sediment. Again, this appears to have taken approximately a millennium to spread from the middle to inner estuary, starting c.1500 cal BC. A rate of rise has been calculated at 1.9mm/year; however, this is based on MSL altitudes calculated using modern tidal range. With index points calculated with historic tidal range, the sea level index points are raised in altitude, and for this phase, the calculated rate of RSL rise must be reduced to possibly as little as 0.3m/year. Furthermore, there is evidence for a drop in MSL during the Roman period of up to 1.5m, the reasons for which cannot, at this point, be explained.

This is a general model; not all the data points fit exactly into it, however, it reflect the general trends shown in the age/altitude and tendency graphs. The new dataset rejects the use of the middle estuary sea level curve and stratigraphic sequences published by Devoy (1979) and supports the model proposed by Long et al. (2000). The use of the modeled historic tidal ranges (and the associated graphs) is offered for discussion as an option for refining age/altitude calculations.

## 11.3 Archaeological datasets

### Introduction

As indicated in Chapter 2, it is possible to use archaeological stratigraphy to assist in reconstructing past relative river and sea levels. This is particularly the case in areas where the archaeological structures were constructed with direct reference to water levels, as may be found in ports, crannogs and coastal settlements. Alternatively, low-lying archaeological sites found in association with estuaries may be used to assist sea level reconstruction either as limiting data or by calculating reference water levels such as MHWST at given periods in given locations. Owing to the accuracy of the dating of many of the Thames structures, and the relative incompressibility of the sediments they are founded upon, these 'limiting' values are arguably more accurate than the age-altitude figures themselves, which are subject to large errors both chronologically and altitudinally. Of the sites analyzed, only Suffolk House (Chapter 10) contained useable archaeological sequences for examining movement of river levels. Therefore, a series of other sites in the Thames floodplain will be discussed in this section, to draw together as much data as possible to assist in RSL reconstruction. They are discussed roughly chronologically and the data are presented in Table 31. This information has been used to generate the values (see Appendix 8) used in the age-altitude calculations discussed above.

### Prehistoric

There are a series of prehistoric sites situated within the study area examined in this thesis. Unfortunately, only one prehistoric dendro date is available from London, and that is not associated with any archaeological stratigraphy (see Chapter 4), which severely reduces the chronological resolution. Nevertheless, there are some archaeological sites in the floodplain that may perhaps be used to provide limiting values for the altitude of the river.

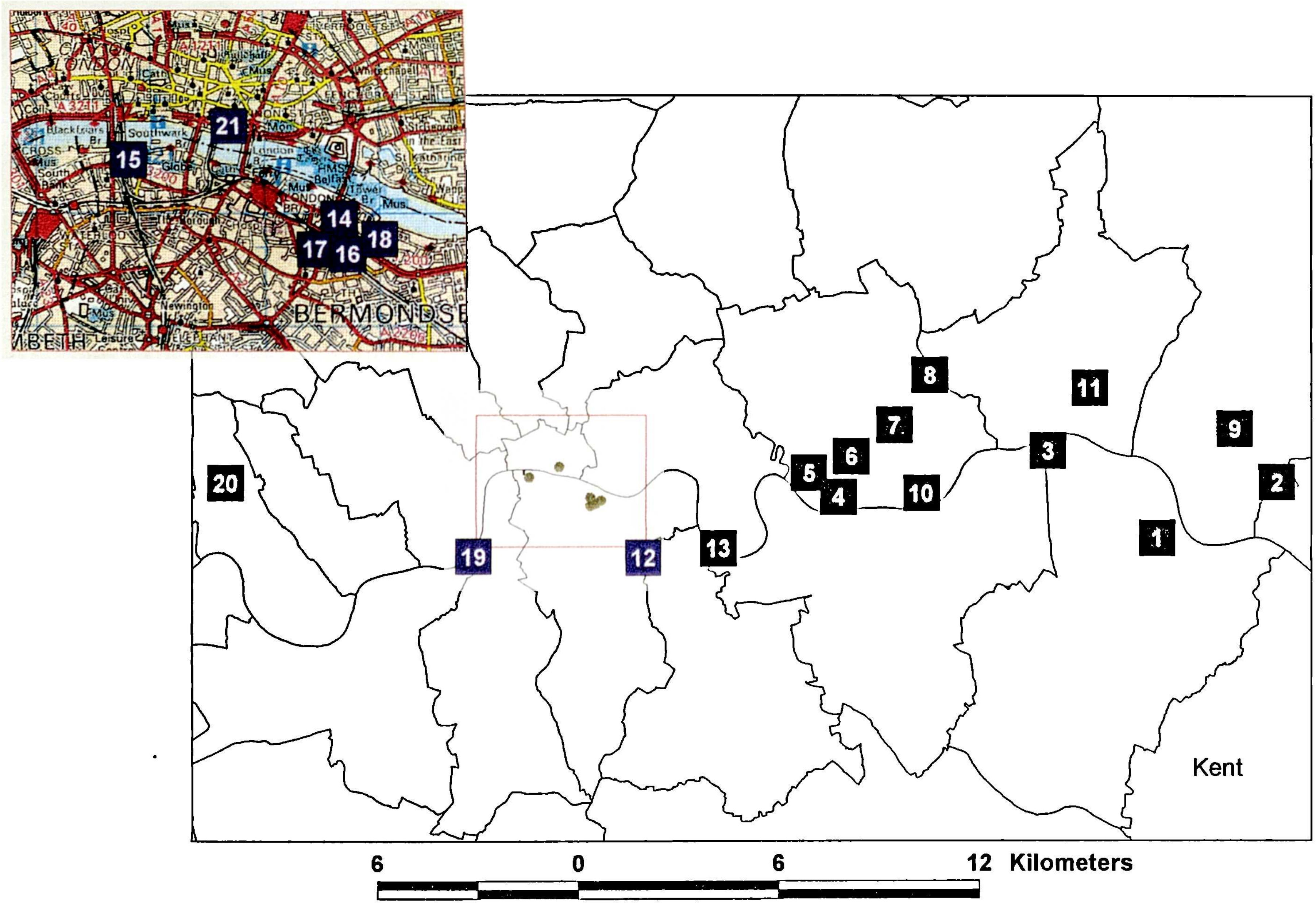



Figure 114. Location map of prehistoric sites mentioned in Chapter 11.3

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Spine Road, Erith | 5060 | 7880 |
| 2 | Wennington Marsh | 5425 | 8025 |
| 3 | Voyagers Quay | 4730 | 8130 |
| 4 | Fort Street Silvertown | 4077 | 8020 |
| 5 | Silvertown Urban Village | 4050 | 8035 |
| 6 | Royal Docks Community School | 4130 | 8110 |
| 7 | Beckton | 4270 | 8200 |
| 8 | Barking | 4380 | 8350 |
| 9 | Rainham | 5280 | 8200 |
| 10 | North Woolwich | 4345 | 7985 |
| 11 | Dagenham | 4860 | 8330 |
| 12 | Bramcote Grove | 3515 | 7805 |
| 13 | Masthouse Terrace | 3750 | 7850 |
| 14 | Three Oak Lane | 3365 | 7984 |
| 15 | Hopton Street | 3182 | 8045 |
| 16 | Phoenix Wharf | 3379 | 7965 |
| 17 | Lafone Street | 3365 | 7960 |
| 18 | Wolsely Street | 3397 | 7975 |
| 19 | Vauxhall | 3020 | 7800 |
| 20 | Fennings Wharf | 3281 | 8037 |
| 21 | Suffolk House | 3271 | 8077 |

Table 29. Sites shown in Figure 114

The earliest of these is the Spine Road, Erith (Bennell 1998, 1 on Figure 114), a Late Mesolithic industrial site situated on the contemporary foreshore, but thought to have originally accumulated above MHWST. This is on the basis of the unabraded and re-fitting flints covering the foreshore (Taylor 1996) that were gradually incorporated into silty sands. The flints are dated to the Late Mesolithic on typological grounds and the base of the peat sealing the foreshore is dated to 5570±90 BP (Beta 88688; 4670-4230 cal BC, -2.65m OD). The two closest sites that have been analyzed are Wennington Marsh (2 on Figure 114) and Voyagers Quay (1 on Figure 114), slightly upstream. The data from Wennington are reasonably consistent with the results from Erith, with a date of 5010±70 BP (Beta 76903; 3960-3650 cal BC) at a depth of -2.55m OD for the inception of peat formation. The results from Voyagers Quay are less comparable. The lowest recorded date here is present at -3.9m OD, much lower than the equivalent deposit at Erith, but dates later, at 4750±70 BP (Beta 93676; 3660-3370 cal BC). At -2.6m OD, close to the altitude at Erith, the deposits date to 3990±70 BP (Beta 93674; 2850-2300 cal BC), but are well into organic formation. It is possible that this discrepancy is due to some natural variation in the altitude of the Pleistocene gravel and/or compression of the Voyagers Quay peats.

(Longest is *c.* 70mm in length)

Figure 115. Flints from the Erith Spine Road, Bexley

The next archaeological site in date is the Fort Street trackway (Crockett et al. 2002, 4 on Figure 114), which is located on the sand bar present in the stratigraphy on the eastern side of Silvertown Urban Village (5 on Figure 114), Chapter 8. The structure is thought to rest on a slightly elevated eyot/bar within the marsh on the north bank floodplain. It is located between -1.28 and -0.99m. OD and dates to the mid Neolithic (see Figure 116). There is some difficulty with the dating of the structure in that the planks and the timbers identified as stakes do not give a consistent date. It seems likely that the date of the planks is more appropriate to use as the stakes could easily be unassociated with the planks and have been driven from above. This gives a date of 4410±60 BP (GU 4407; 3340-2910 cal BC). The peats in the area are likely to be forming slightly above MHWST and therefore the sand island is raised above this, giving a reasonable limiting level for the river. By comparison with the Silvertown Urban Village, there is some discrepancy between date and altitude. The closest match is 5010±70 BP (Beta 120960; 3960-3660 cal BC) at -1.0m OD, but this is still several hundred years earlier than the Fort Street structure. The fact the trackway is on a raised island probably makes for the problems of comparing age/altitude points.

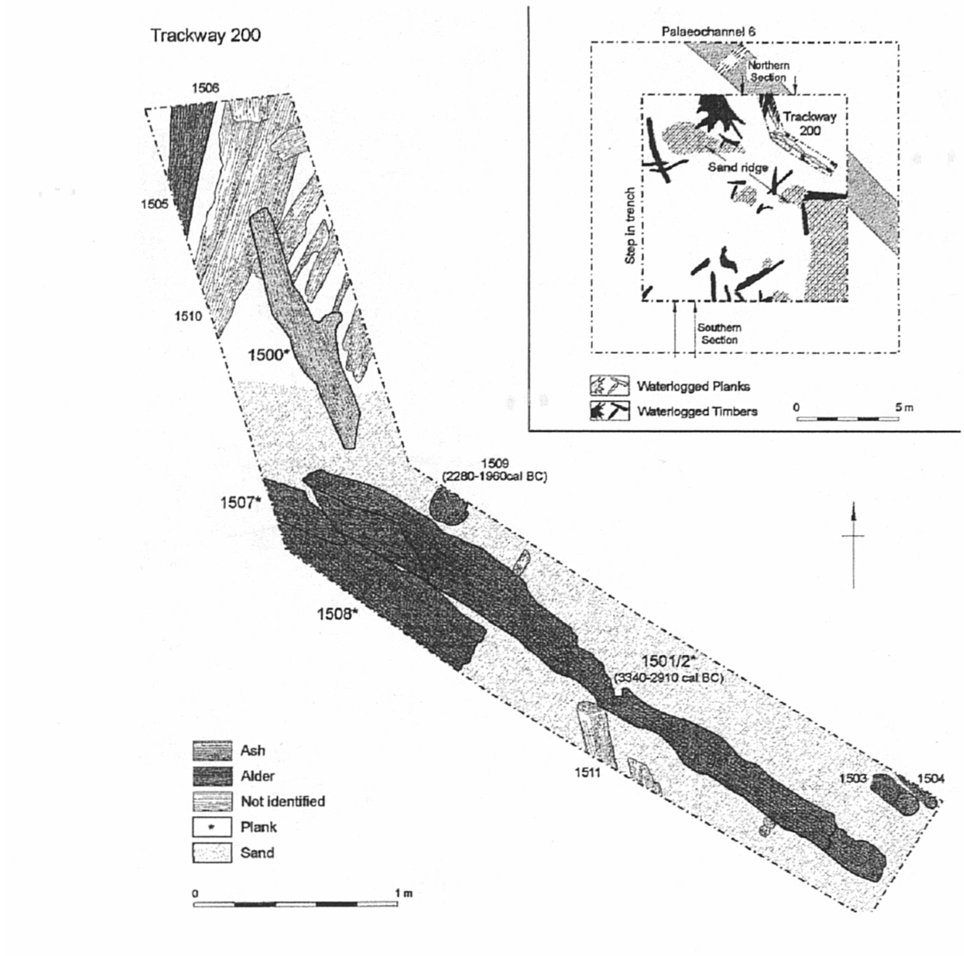



**Figure 116. Fort Street trackway, from Crockett et al. (2002)**

A site slightly to the east of the Silvertown trackway is the Royal Docks Community School, Custom House (Holder 1998, 6 on Figure 114), a sand eyot raised slightly above the level of the surrounding marsh at *c.* 0.5m OD. This was capped with an eroded occupation surface with spreads of flint, pottery and a series of features with a timber platform. The island seems not to have been a settlement site but rather a location that was sporadically visited and used for a variety of purposes. The pottery dates from the Late Neolithic to the Middle Bronze Age with Deverel Rimbury and Peterborough Ware forms present (Holder 1998). A date from the buried soil was 3080 ± 50 BP (Beta 118940; 1430-1200 cal BC) with a subsequent date for the top of the buried soil, which was sealed below (presumably estuarine clay) of 2490 ± 50 BP (Beta 118939; 800-400 cal BC, 0.5m OD). This indicates that this part of the estuary was flooding to at least 0.5m OD by the mid Iron Age.

To the north and east of Custom House is a series of Middle Bronze Age timber trackways, often buried within alder carr peat, slightly below the top of a substantial peat. These are generally made from uncoppiced alder of brushwood bundles and are found in Beckton and Barking (Meddens 1996, 7 and 8 on Figure 114). They were used to facilitate crossing the boggy marshes, possibly for both functional and ritual activities. Two examples are found at Beckton. At Beckton 3-D a cradle supported trackway (Figure 25) was recovered at c -2m OD with a date of 3070±80 BP (Beta 68578; 1520-1100 cal BC). A similar structure was found in a large peat bed at Beckton Nursery, dating to 3080±50 BP (Beta 76885; 1430-1220 cal BC, -2.1m OD). Others have been found in Rainham and North Woolwich (9 and 10 on Figure 114), all dating to the Middle Bronze Age and generally just below the top of the peat. North Woolwich pumping station is relatively close to these sites, however, altitudinally higher at this date, which may simply argue for greater consolidation at Beckton where thicker peats are present than at Woolwich.

It seems likely that a mid Bronze Age stone causeway in Dagenham (Meddens 1996) (11 on Figure 114) was used for moving livestock into the marshes here. The causeway is located at -1.7m OD and is dated to the period between 3380±80 BP (Beta 70882; 1880-1520 cal BC) and 2960±80 BP (Beta 70881; 1400-1000 cal BC), as these are the dates obtained from peat directly below and above it. This is likely to be above MHWST if indeed it was used to facilitate a pastoral economy. However, other interpretations are possible, such as a routeway to the river for people, for either ritual or functional purposes. The closest analyzed site on the north bank is Wennington, where a comparable date of 3320±70 BP (Beta 76903; 1680-1320 cal BC) at -1.35m OD was recovered from the transgressive contact. Voyagers Quay is almost directly opposite Dagenham, but the results are less comparable, with a date of 3020±60 BP (Beta 93673; 1430-1020 cal BC) obtained from the transgressive contact at -1.9m OD. This, as with the Erith site mentioned above, may indicate differential compression at Voyagers Quay with younger dates at lower altitudes than elsewhere.

Several trackways have now been studied from the south bank; indeed there is a contemporary one at the Erith Spine Road to those on the North Bank (Bennell 1998). It is a slightly different build (see Figure 117), being a hurdle panel of double sailed type of coppiced alder (with a few fragments of hornbeam, pine and oak), and dates to 3210±90

BP and 3010±80 BP (Beta 88689/90; 1700-1300 cal BC and 1440-1010 cal BC). It was contained towards the top of an alder carr peat (Sidell et al. 1997) at -1.22m OD. Again, this may indicate differential compaction at the nearby site of Voyagers Quay, whilst it is reasonably comparable with the transgressive contact at Wennington.

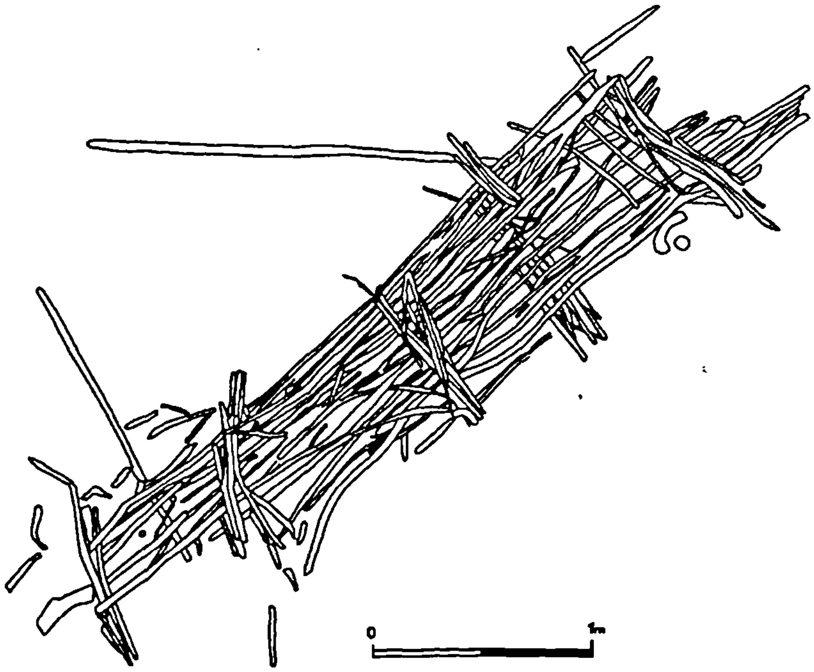



Figure 117. Drawing of the Erith trackway, from Bennell (1997)

Another trackway is present at Bramcote Grove (12 on Figure 114) in the Bermondsey floodplain (Thomas and Rackham 1996), in the marsh extending over an infilled relict lake basin (see Figure 118). It is unusually formed of oak trunks and is slightly earlier than the roundwood trackways, dating to 3350±60 BP/3410±70 BP/3370±60 BP (Beta 70410/11/12; 1740-1530 cal BC) at an altitude of -1.1m OD. The closest analyzed site to Bramcote is Masthouse Terrace (13 on Figure 114) across the Thames on the Isle of Dogs, however, the results are not a good comparison; a date of 3920±80 BP (Beta 85218; 2620-2140 cal BC) is the closest, however it is at an altitude of -2.75m OD); significantly lower than the Bramcote trackway, but only a few hundred radiocarbon years earlier. This may be associated with the different sedimentary environments; Bramcote filled in a relict lake basin whilst Masthouse Terrace appears to have been in a much more dynamic environment, affected by local channels and the Thames itself.

In summary, the trackway sites have a number of similarities. They are generally constructed in the mid-Bronze Age at the top of peat sequences when the peats appear to be getting increasingly waterlogged, but are thought to reflect a level above MHWST. The number of such occurrences indicates that this is a widespread trend in the area of east London, and perhaps can be taken as a good indicator of rising water levels.

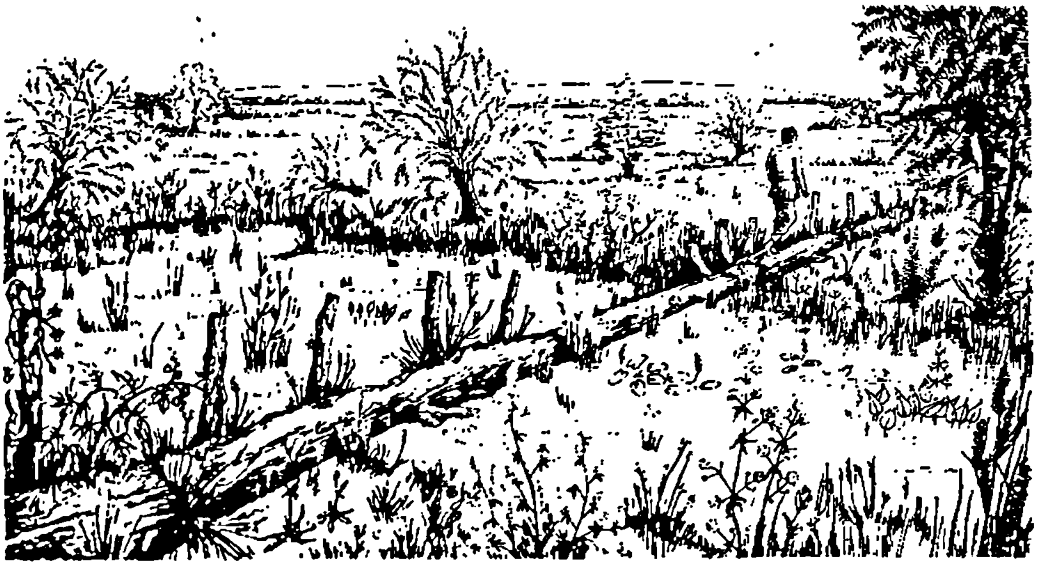


Figure 118. Reconstruction of the Bramcote trackway, from Thomas and Rackham (1996)

In addition to the trackway sites, there is evidence for field systems that can also be used as limiting data, as they must have been above the river to function. They are identified as arable on the basis of the ard marks found on the sites, and indeed the ard share (Figure 119) found at Three Oak Lane (Proctor 2000, 14 on Figure 114). There are possibly two phases of activity, starting at Hopton Street (15 on Figure 114) in the west, where a series of ard marks was found sealing a pit with a placed deposit of a very unusual Beaker bowl. This has been interpreted as a ritual deposit, placed prior to taking the land into cultivation (Sidell et al. 2002) and has been used to date the site to approximately 2000 cal BC, present at +0.7m OD. This is higher than the second phase, at c. +0.4m OD, centred upon Phoenix Wharf (Sidell et al. 2002, 16 on Figure 114), Lafone Street (Bates and Minkin 1999, 17 on Figure 114), Wolsely Street (Drummond-Murray et al. 1994, 18 on Figure 114) and Three Oak Lane.

All of these sites exhibit ard marks, but none have placed artefactual deposits. They are all within a hundred metres of each other and the marks are on the same alignment, within a degree or so and have been interpreted as a co-axial system (Sidell et al. 2002). However, dates are only available from Lafone Street where the soil itself was dated to 3100±60 BP (Beta 107981; 1520-1220 cal BC); its assumed that all sites are contemporary. The eastern group may be altitudinally lower than Hopton Street because the higher land was used initially and expanded to use the lower ground at the edge of the eyot chain. These must have been slightly above the river, or it would not have been able to cultivate the area if there were regular incursions of salt water. However, the soil was thin and sealed by estuarine clays, indicating that the sites were not long-lived.

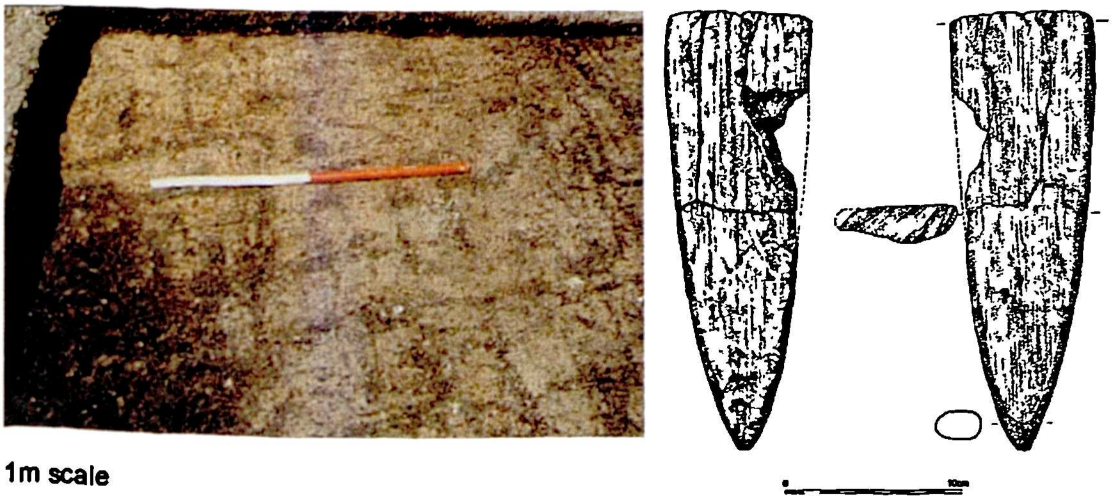



Figure 119. Ard marks found at Phoenix Wharf and ard share found at Three Oak Lane, Southwark, from Merriman (1990) and Proctor (2000)

Further upstream, at Vauxhall (19 on Figure 114) a Bronze Age timber structure, interpreted variously as bridge, jetty or platform (Milne 2002) has been found on the modern foreshore. Several mid Bronze Age side-looped spearheads were found tied together and rammed into the contemporary surface. Traces of marine diatoms were found in sealed deposits thought to be associated with the contemporary surface (identified by Cameron, unpublished). The structure is present at varying altitudes down the foreshore and yielded a radiocarbon date of 3380±40 BP (Beta 122970; 1770-1520 cal BC) and 3180±70 BP (Beta 122969; 1620-1260 cal BC). The working surface here is thought to have been above MHWST, as this is usual for a functioning structure.

However, it has been suggested that the structure may have been built as a platform for throwing offerings into the river to 'placate' the rising waters (Sidell et al. 2002) and offerings may also have been floated off by the tide. Unfortunately, this is an issue that cannot be resolved. The working surface has not survived and therefore must be conjectured. The highest pile (landward end) survives to -1.3m but was initially buried and then recently eroded. It seems unlikely that the working surface would have been any higher than necessary, for ease of access, and so a figure around -1.3m may be likely.

Moving into the Late Bronze Age, a site at Fennings Wharf (20 on Figure 114), records an Early Bronze Age barrow (Sidell et al. 2002), located on a contemporary promontory jutting out into the Thames. Although the barrow and its associated cremations are the core feature of the site, archaeologically speaking, it is the later re-use of the site that is relevant here, in that the site, located at 1.0m OD must still have been above high water at approximately 700 BC when some distinctive clay slabs were deposited in a secondary cremation.

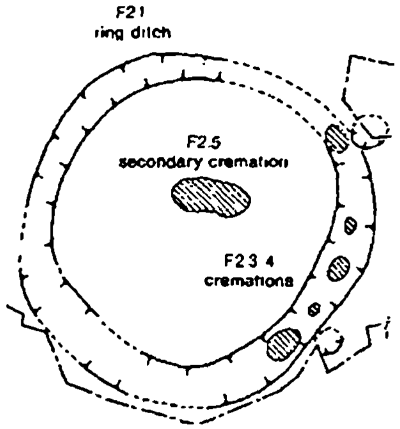



Figure 120. The Fennings Wharf barrow (*c.* 8m diameter) from Watson et al. (2001)

This site is relatively close to Suffolk House (Chapter 10, 21 on Figure 114), across the river in the City, however, the date is not wholly comparable. A peat sample there at +0.1m OD dated to 2070±70 BP (Beta 96089; 790-400 cal BC) which indicates that the Fennings Wharf site was still well above the river at the time of re-use. Nevertheless, the site had been submerged in the immediate pre-Roman period (Watson et al. 2001, 11).

## Summary

The examination of prehistoric archaeology associated with the river is indicative of past river levels, generally as limiting data. Unfortunately it is rarely possible to obtain good chronological control for this period. Neither is it generally possible to establish a link with activity and a reference water level. Nevertheless, the available data is generally consistent with the model of tendency along the estuary and also with the age altitude data calculated with the older historic tidal ranges.

## Roman

The archaeological data for the Roman and subsequent periods are more precise indicators for the Thames levels. As shown above Suffolk House (1 in Figure 121) demonstrates a southwards and downwards movement of the working surfaces of the Roman quays. The main assumption that must be made if the archaeological structures are to be used is that the working surface of the quays has a direct altitudinal relationship with river levels. This is an important assumption, but it seems likely that waterfront structures are constructed with the most efficient use in mind, i.e., that they should always have been available and not be subject to flooding except in extremely rare conditions. It is likely that the initial Roman build may not have been in the most suitable place owing to the shortness of time to observe tidal patterns. With the exception of the first quays, it should be safe to assume that the waterfront is generally situated at approximately HAT to incur the least amount of flooding possible. If the working surfaces were too high, then there would be problems in actually getting the boats up to them and create difficulties with loading and unloading cargo, which is thought to have included livestock; best walked on and off boats.

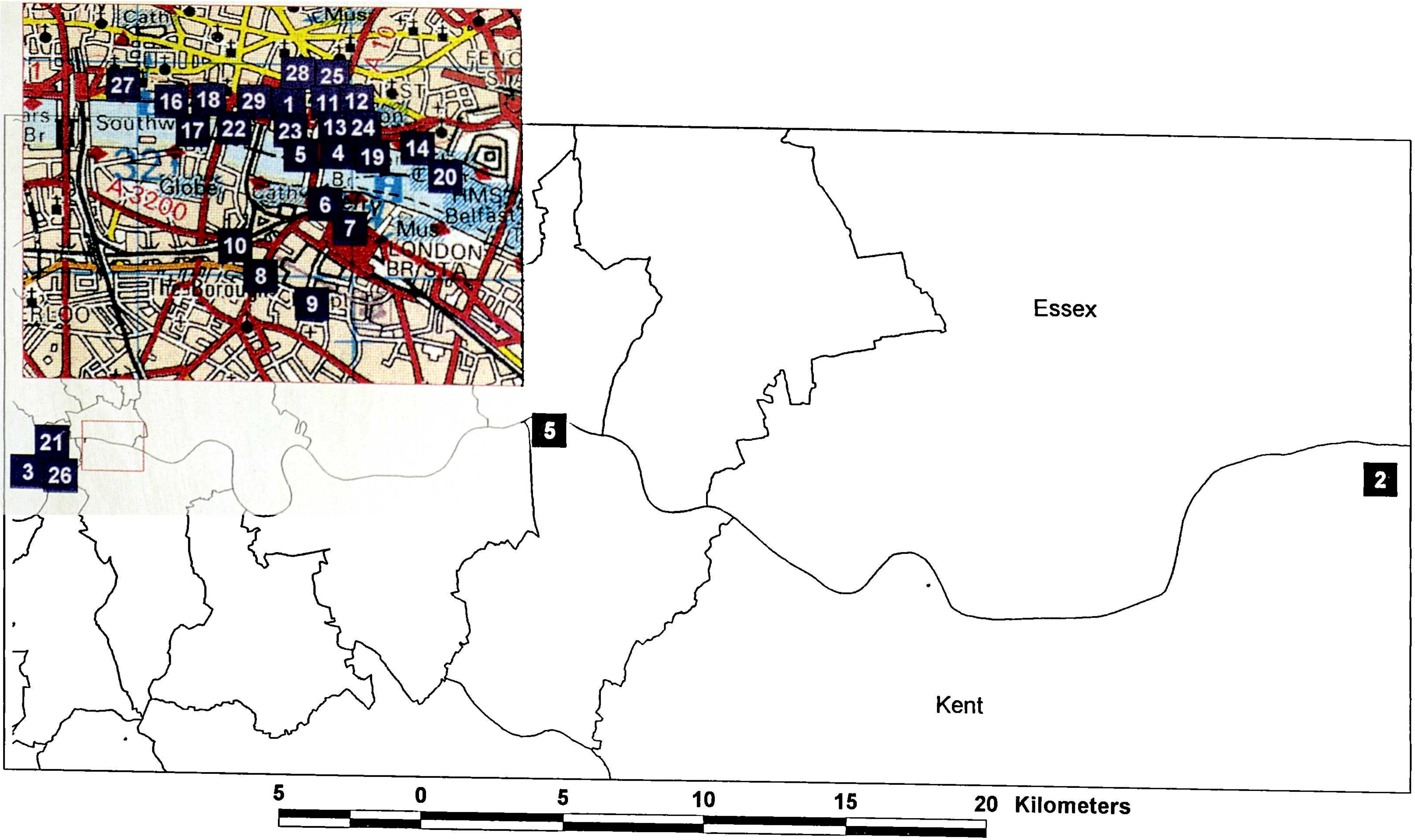



Figure 121. Location map of historic period sites mentioned in Chapter 11.3

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Suffolk House | 3270 | 8078 |
| 2 | Summerton Way | 4800 | 8128 |
| 3 | New Palace Yard | 3018 | 7964 |
| 4 | New Fresh Wharf | 3295 | 8066 |
| 5 | Brentford | 1740 | 8000 |
| 6 | Fennings Wharf | 3286 | 8037 |
| 7 | Toppings Wharf | 3287 | 8036 |
| 8 | 64-70 Borough High Street | 3256 | 8006 |
| 9 | Guys Channel | 3281 | 7992 |
| 10 | Courage Brewery | 3252 | 8011 |
| 11 | Regis House | 3288 | 8072 |
| 12 | Pudding Lane | 3294 | 8072 |
| 13 | Billingsgate Buildings | 3301 | 8069 |
| 14 | Custom House | 3332 | 8058 |
| 15 | Seal House | 3277 | 8067 |
| 16 | Queenhithe | 3230 | 8080 |
| 17 | Bull Wharf | 3232 | 8079 |
| 18 | Vintry | 3237 | 8081 |
| 19 | Billingsgate lorry park | 3305 | 8062 |
| 20 | Three Quays House | 3335 | 8055 |
| 21 | Northumberland Avenue | 3020 | 8034 |
| 22 | Thames Exchange | 3245 | 8075 |
| 23 | Swan Lane | 3273 | 8070 |
| 24 | Trig Lane | 3301 | 8069 |
| 25 | Millennium Bridge | 3290 | 8079 |
| 26 | Thorney Island | 3022 | 7962 |
| 27 | Baynards Castle | 3194 | 8090 |
| 28 | Miles Lane | 3284 | 8075 |
| 29 | Dowgate Hill | 3252 | 8082 |

Table 30. Sites shown in Figure 121

There is only a very limited amount of Roman material in the floodplain outside the modern City and Southwark. The site at Summerton Way (Lakin 1999, 2 in Figure 121) is a useful indicator of apparently dropping and then rising river levels in that the stratigraphy demonstrates a transition from alder carr (c. -1.6m OD) to freshwater muds (-0.7m OD) and then mid Roman terrestrial deposits forming on the earlier foreshore, subsequently sealed by estuarine muds at -0.4m OD containing Late Roman pottery. Further upstream at New Palace Yard, Westminster (3 in Figure 121), the 3rd century high water was thought to be comparable with heights at New Fresh Wharf (4 in Figure 121 and see below) at approximately 0.5m OD (Evans no date) and the same appears to be the case at Brentford (Wheeler 1929, 5 in Figure 121).

Southwark is an important area owing to the low-lying nature of the eyots that were initially colonized by the Roman settlers. There are some problems caused by the reclamation of the area and the use of river defences that must have protected some sites situated below MHW; analogous to the modern Thamesmead estate, which is situated four metres below MHW. Nevertheless, the sheer volume of work carried out in Southwark over the last thirty years does allow some analysis of river levels. In the pre-Roman period, river deposits had overtopped Fennings Wharf (6 in Figure 121), above +1.0m OD and nearby Toppings Wharf (Sheldon 1974, 7 in Figure 121) and indeed much of north Southwark (Yule 1988). This appears to have been the level settled and revetted by the Romans, as much artefactual debris from the mid-1st century AD is present in the upper levels of the river silts, thought to have formed at pre -Roman HAT (Watson et al. 2001).

Evidence to support this comes from Toppings Wharf (Sheldon 1974), where a gravel embankment was found on the AD 50-80 Roman foreshore, reconstructed to possibly 2.0m OD (Watson et al. 2001, 12). It is thought to have been used to protect the settlement from the highest tides. Furthermore, a series of roads were built at +1.5m OD, crossing Southwark and heading for the bridgehead (Milne 1985, 81) with no signs of having been flooded.

Further support comes from 1st to 2nd revetments at 64-70 Borough High Street (Graham 1988, 8 in Figure 121). These have been reconstructed up to 1.75m OD. A more spectacular discovery was the Courage Brewery warehouse (10 in Figure 121), built over intertidal deposits in AD 152 at 0.5m OD, and thought to be below MHW (Brigham et al. 1995). The 3rd century revetments in the Guys Channel (9 in Figure 121) can be reconstructed to 1.0m OD (Taylor-Wilson 1990) and indicates a drop in water level. This albeit fairly scanty evidence from Southwark corresponds reasonably well with figures from the City side.

The north bank was heavily developed in the Roman period, with an apparent mixture of 'official' waterfronts, constructed under the auspices of the provincial governor and some unofficial stretches thrown up by the tenants or owners of waterfront properties. These were well constructed oak quays and revetments founded on the gravel foreshores (see Milne 1985; Brigham 1990). They stretched a kilometre along the Thames, roughly 500m either side of modern London Bridge (Perring and Brigham 2000), with rather less intensive development at the extremes of this range.

The earliest evidence for the Roman waterfront in the City has been found at Regis House (Brigham et al. 1996, 11 in Figure 121) with a very rough revetment dating to AD 52 along a terrace between 2.0 and 2.5m OD. This was subsequently replaced shortly after spring AD 63 with a more robust quay, presumably constructed after the Boudican destruction of AD 60 with the upper surface at 1.6m OD. It is suggested that this substantial variation in height is due to placing the early revetment too high in relation to the river level, rather than a drop in mean river level of nearly a metre in a decade.

The Regis House quay is almost certainly associated with the 1st century quay from Pudding Lane (12 in Figure 121), dated to AD 59-74 (probably AD 60-65). Foreshore samples collected in association with the Pudding Lane quay were rich in the diatom taxon *Cyclotella striata* (Bateman and Milne 1983), demonstrating the tidal nature of the Thames here in the 1st century. The Regis waterfront was rebuilt to the south in AD 102, again on a line with the AD 95-100 waterfront at Pudding Lane (Bateman and Milne 1983; Watson et al. 2001, 31), but at a decreased height from the Neronian quay, at 1.38m OD. Following the Hadrianic fire that razed the area to the ground and led to a substantial accumulation of debris, the waterfront was once more moved south, possibly by eight metres. It is proposed that at Pudding Lane, a 3rd century quay was advanced again to the south, present on the site of New Fresh Wharf (discussed below). This consistent movement and reduction of altitude suggests that river levels were indeed dropping and if the waterfront was to function, it had to be relocated periodically.

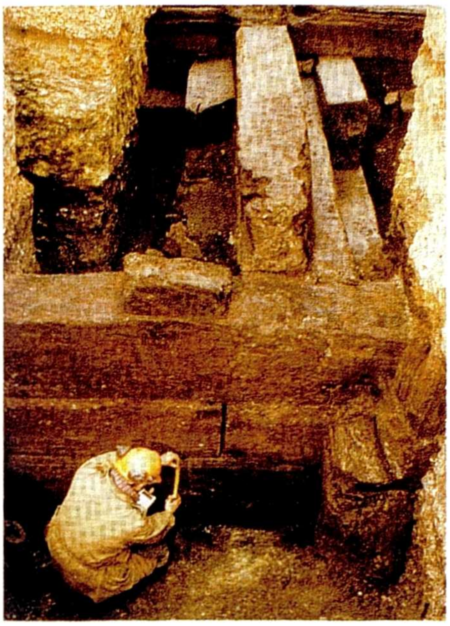


Figure 122. Neronian quay from Regis House

Excavations at Billingsgate Buildings (13 in Figure 121) in 1974 revealed further Roman waterfront structures (Jones 1980). The first of these dates to between AD 70-100 and survives to +1.6m OD but is not thought to be quite complete. A contemporary quay at Pudding Lane is complete and survives to +2m OD ((Milne 1985, 81), with diatom samples from the foreshore deposits containing species such as *Cyclotella striata, Cymatosira belgica* and *Delphineis surirella* (Milne et al. 1983) but dominated by brackish and freshwater species such as *Fragilaria pinnata*. A second revetment at Billingsgate was built shortly after, between AD100-125, three metres to the south. Again this did not survive to the full height, however, it is notable that it is built significantly downslope of the first revetment with the base below OD whilst the base of the first revetment is at +0.5m OD. A third revetment was built between AD 125-160, five metres to the south with the base projected at -0.75m OD and the top at +1.5m OD. Although not recovered on site, a fourth revetment to the south is indicated on the basis of the dumping levels in front of and over the third revetment which are similar to the dumps over and in front of the previous revetments. No date is suggested for this putative fourth revetment. The publication suggests that these revetments were on the foreshore, but above the river, on the basis of no waterlain sediments surviving - this was identified as controversial when written and also this was before the publication of much of the waterfront. It is apparent now that Billingsgate Buildings demonstrates consistency with other stretches of the waterfront, showing a consistent response to fluctuations in water level.

At Custom House, (Tatton-Brown 1974, 14 in Figure 121) pre-Roman river levels were identified at > -1.5m OD. The report argues that environmental data indicate the Thames was fresh in the Roman period, but this is not supported elsewhere (Wilkinson 1998). Two waterfronts were recovered; an early 2nd century (AD 140-43, Fletcher 1982) revetment at below 0.5m OD and a later 2nd century (probably AD 180-190) box structure, six metres to the south of the first quay. The later 2nd century MHW is estimated to be at OD, with MLW below -1.6m OD (base of the box structure) on the basis of the quay heights. There is a question over whether the site was tidal at this date as the published interpretation indicates freshwater conditions. Nevertheless, by analogy with the modern Thames, which is freshwater at Teddington Lock, the 2nd century Thames could have been weakly tidal at Custom House. If not, this almost certainly puts the river levels below -1.5m OD, as it would not have been practical to build the quay under water. However, examination of the environmental report shows that only a few seeds were examined; no pollen, diatoms or other indicators are reported. Therefore, it is possible that the data (8 seeds) may have been over-interpreted. The late 2nd century quay here was not replaced and appears to have been submerged in the 4th century, with foreshore material (and subsequently the late 13th century quay) deposited over it. It seems likely that the waterfront shrunk in length as time passed with rebuilds only occurring in the centre.

The late 2nd century quay was also found at Seal House (15 in Figure 121), dated to AD 171, with the base at -1.75m OD. It was not complete, but the third tier was found at -0.41m OD (Brigham 1990). However, a working surface with building remains was found at +0.4m OD a few metres to the north of the structure which has led to a projected reconstruction (see Figure 123) at that height. At Queenhithe (16 in Figure 121), the AD 198 quay was preserved, but badly damaged. Analysis of the associated sediments indicated that the water was saline but only weakly so (Wilkinson 1998), with the base of the structure at approximately -1.8m OD and the top surviving only to 0.0m OD.

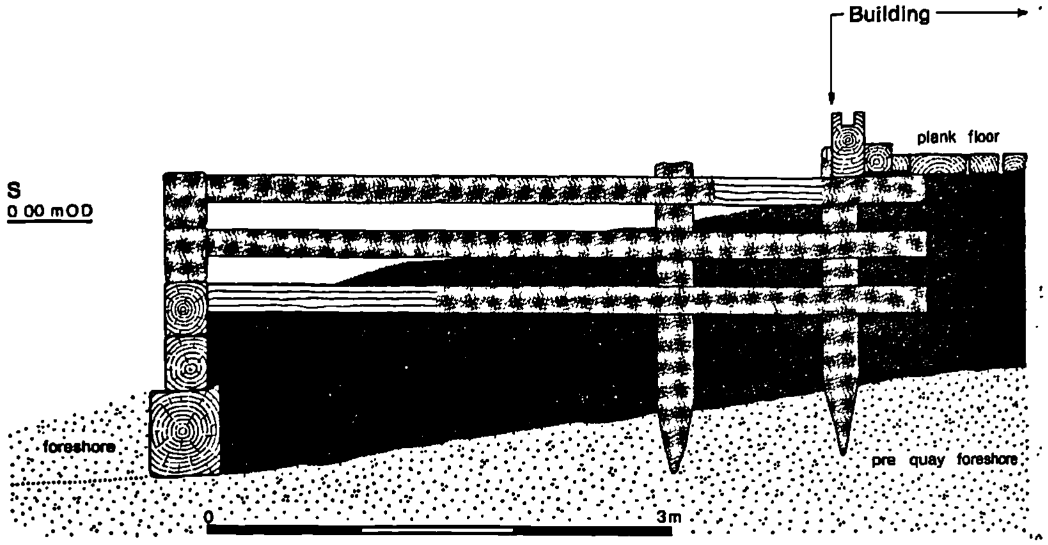



Figure 123. Reconstructed cross-section through Seal House late second century waterfront. Extant timbers are shown with grain, from Brigham (1990)

At New Fresh Wharf, the Late Roman waterfront was present at +0.5m OD, with the base at approximately -1.5m OD (Miller 1986). At the Billingsgate lorry park (19 in Figure 121), adjacent to New Fresh Wharf a box style quay with a crane installation was found, dating to AD 201-228 (Brigham 1990) -comparable with the late phase at New Fresh Wharf of AD 209-224. The quay was rebuilt in 239-75, possible at the time of wall building to the north. The working platform was at approximately -0.6m OD but was protected by a raised waterfront to approximately +0.5m OD.

The end of the timber waterfront occurred in the mid 3rd century when it was partially dismantled or chopped through, approximately 25 years before the construction of the 3rd century river wall, to the north of the 3rd century quays. Evidence from the wall at Three Quays House (20 in Figure 121), indicates river levels were still declining in AD 270, with MHWST thought to be below OD on the basis of the foundation levels found here (Grainger 1996).

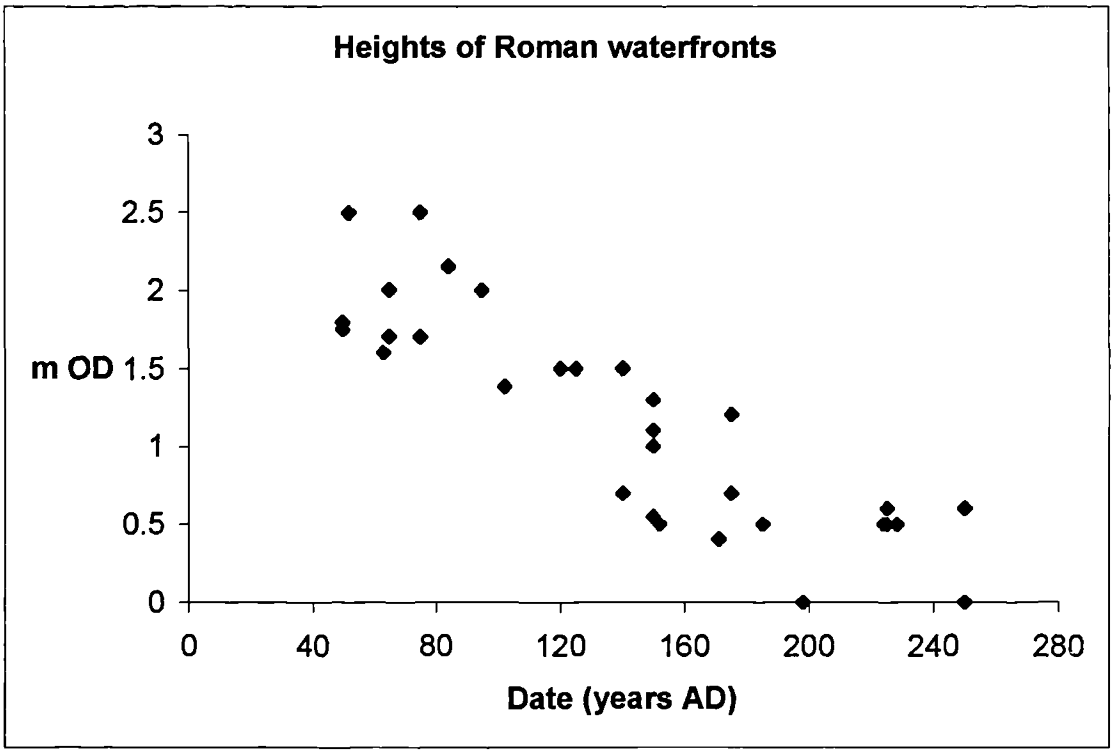



Figure 124. Graph of the altitudes recorded for the top of the Roman waterfronts

This graph shows relatively clearly how the waterfront decreased in altitude over time. It indicates that the waterfront levels were fairly consistent at some periods, and are likely to have been the result of centralized planning. There is certainly some scatter, but the Early Roman scatter is likely to be a result of 'frontier town' mentality and a lack of familiarity with the river in conjunction with the need to create a functioning waterfront.

## Summary

The Roman sites show reasonable consistency at a broad scale, with gradual decline in altitude of the working surfaces from the first builds of the waterfront through to the final river wall in the 3rd century. This is summarized in Table 31 below and also on Figure 117. Most significantly, what all the data from these numerous sites indicate is a drop in relative river levels of up to 1.5m between the late 1st to the 4th centuries. The earliest heights are not considered in this because it seems likely that the initial colonization of the City placed the waterfront too high.

## Saxo-Norman to medieval

Subsequent to the Roman period, there is thought to be no occupation within the City for several hundred years, with sporadic activity only. No structures are noted until the Alfredian deposits at Queenhithe (Ayre et al. 1996), around AD 890 and then from AD 900 elsewhere (Steedman et al. 1992, 14). Saxon river silts and foreshore gravels seal the Roman waterfronts and defensive wall, noted from sites such as Custom House (Tatton-Brown 1974), New Fresh Wharf (Miller 1986) and Queenhithe (Ayre et al. 1996). It appears that there was a relatively rapid rise in river levels during the early part of the Saxon period that subsequently leveled off in the Early Saxo-Norman period with MHWST at approximately 1.6m OD in the City, with HAT reaching *c.* 1.9m OD (Watson et al. 2001, 27) and remaining fairly consistent into the 15th century (Milne and Milne 1982). LAT is calculated at no higher (and possibly lower) than -1.5m OD for this period, on the basis of the lowest structural elements, the revetment baseplates. The earliest evidence comes from the Strand area, where a Saxon riverside embankment was dated to AD 679 or very shortly after at Northumberland Avenue (Cowie and Whytehead 1989; Cowie 1992, 21 in Figure 121) present to a height of 1.3m OD, presumably associated with the settlement of Lundenwic.

Queenhithe contains one of the most complex Saxo-Norman sequences on the London waterfront. The Alfredian late 9th century quay overlies the remains of the Roman quay, slightly to the north but separated by 1.5m of sediment and with the top at *c.* 1.5m OD. The second phase of material from Queenhithe dates to AD980-1014 with revetments surviving to 1.45m OD, thought to be MHWNT on the basis of patching and erosion. The base of the structure was at 0.5m OD and this is thought to represent no lower than MLWST and probably MLWNT for ease of construction. In AD 1045-6 a timber bank was constructed approximately four metres to the south, with its base at *c.* -1.5m OD. This is taken to indicate a drop in mean river level on the basis of the bottom of the bank being a metre lower than the earlier revetment.

The subsequent waterfront was constructed to the south in 1120-21 at a higher elevation (1.5m OD), with the base now at -0.4, slightly higher than the AD980-1014 waterfront. However, a new revetment was needed only a few decades later in 1145-47, eight metres to the south and this dropped once more with the base at approximately -0.5m and top at *c.* 1.4m OD. A further revetment was built in 1165-70, another five metres to the south, but with top and bottom levels the same as the previous quay. This then may indicate reclamation rather than adapting to changing river levels. The final Queenhithe revetment, built in 1181 was present to *c.* 1.8m OD with its foundations at *c.* 0.0m OD. This rather sudden raising of levels is thought to be associated with the construction of the first stone-built London Bridge (begun in 1176, completed in 1209), the 19 piers of which halved the width of the river at that point, leading to a weir effect on the upstream side (Ayre and Wroe-Brown, pers. comm.).

Slightly to the east of Queenhithe, the site of Thames Exchange (22 in Figure 121), excavated in 1988-9 also contained a series of Saxo-Norman waterfronts, the first of which overlay an earlier Roman quay (Milne 1992). The first Saxo-Norman quay (TEX1) dated to AD967-89 with a working surface at *c.* 1.65m OD. The waterfront advanced at a further eight times, gaining approximately 70m into the river by 1239 where the working surface of TEX9 is estimated to be at 2.2m OD.

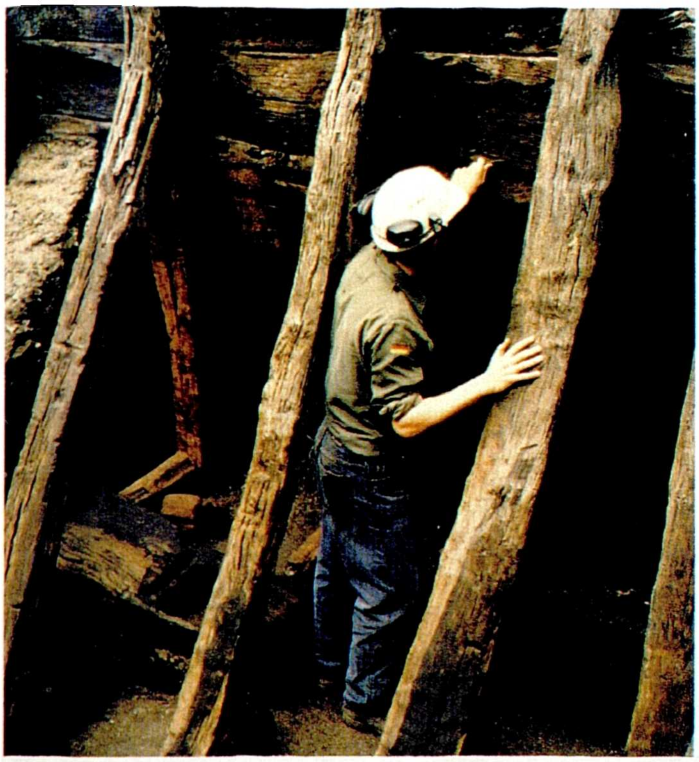


Figure 125. TEX4 under excavation, from Milne (1992)

At New Fresh Wharf, the initial Saxo-Norman build was a rubble bargebed to the south of the Roman quay at a level of -0.34m OD, and dated to slightly after AD 955. A nearby series of timbers (interpreted as a jetty - see Figure 126) survived to a maximum of 1.6m OD, which is thought would have been covered at HAT but not MHWST (Steedman et al. 1992, 102). The jetty seems to have been abandoned and replaced in the mid 11th century by a series of individual embankments representing property boundaries, going up to approximately 2.0m OD, just above HAT, but much of the structure appears to have been below this and therefore subject to periodic flooding. These were consolidated in the late 11th and again in the 12th century but with no apparent raising up of levels. Revetting continued into the late 12th century by which point the waterfront here appears to have been firmly consolidated against an apparently stable tidal level.

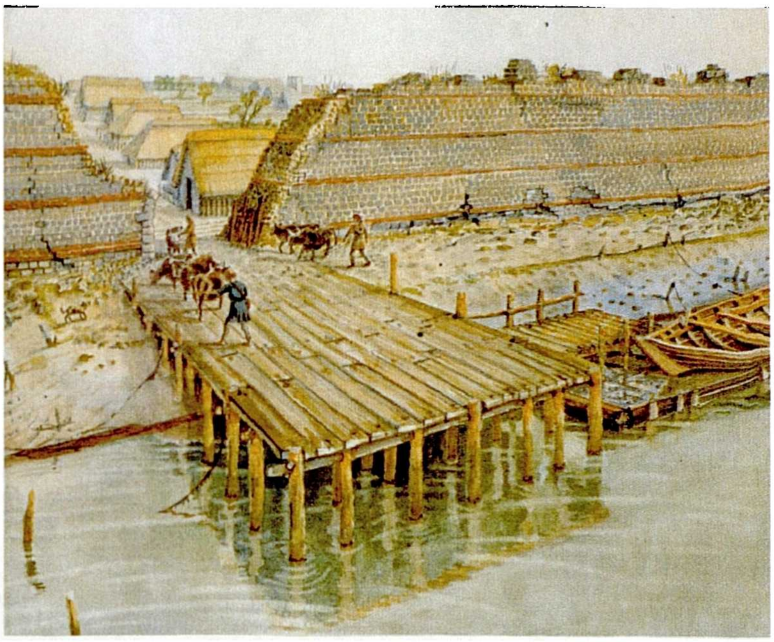


Figure 126. Reconstruction of the Saxo-Norman timber jetty at New Fresh Wharf, from Steedman et al. (1992)

At Swan Lane (23 in Figure 121) the first post-Roman embanking took place in 1050-80 at 2.5m OD to the north, dropping to 1.3m in the south (Steedman et al. 1992, 113). A further late 11th century embankment extended 2.5m to the south of the earlier Roman quay, with a height of about 1.9m (contemporary HAT). The adjacent Seal House sequence starts with a revetment dating between 1133-70 (baseplate at -1.5m OD, working surface at c. 2.0m OD), then a new one to the south in 1163-92, thought to have a working surface at 1.2m OD, although this would have been below MHWST. A final waterfront was constructed in 1210, 6m to the south again at 1.2m OD. These do not make sense, being apparently below MHWST and therefore only much less usable than structures above MHWST. The Seal House structures can only have been used to load and unload boats drawn up on the foreshore. Beach markets or *ripa emtoralis* are known from slightly earlier, and it is possible that they continued to this date (Dyson 1978; Ellmers 1981). However, the possibility of inter-tidal waterfronts at Seal House must mean a note of caution should be introduced when considering the waterfront in its entirety.

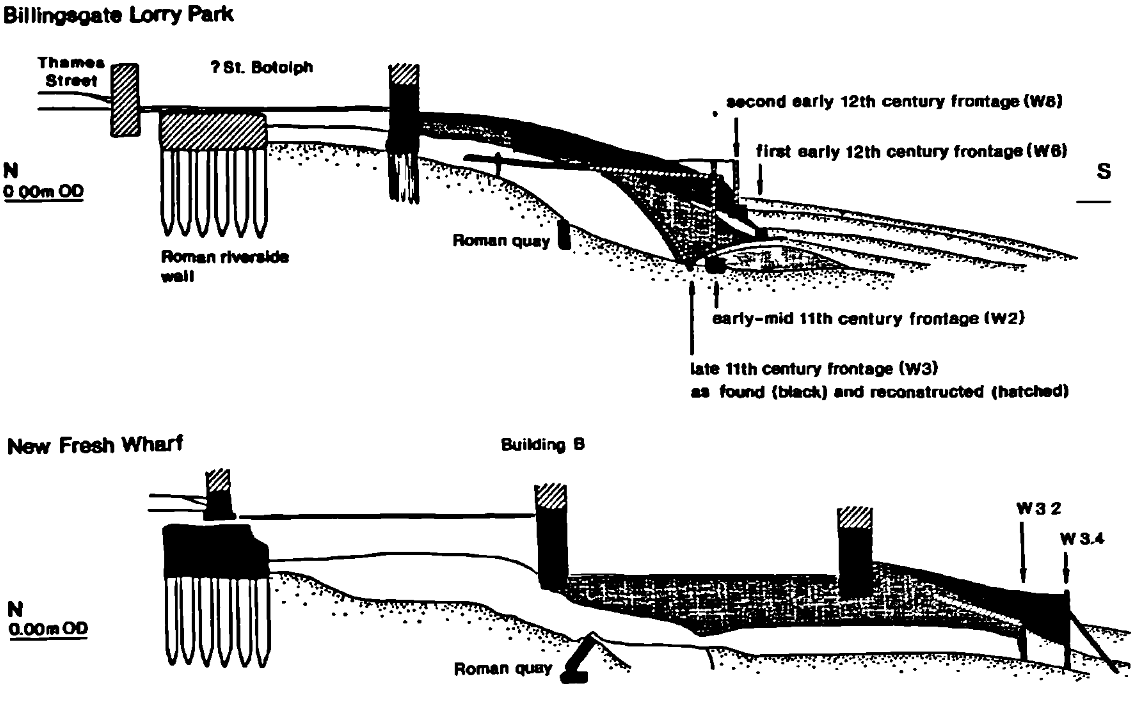



Figure 127. Cross-section of sequence from New Fresh Wharf and Billingsgate, from Steedman et al. (1992)

There is also medieval evidence from Custom House (Tatton-Brown 1974) where the late 13th century quay was built over the over the second century quay which was sealed by Saxo-Norman foreshore deposits. This was a fairly crude structure, using old timbers and significantly different from the elegant boxed quay below it. A much better constructed revetment replaced it shortly after, six metres to the south, reconstructed to approximately 1.9m OD and almost certainly dating to the early 14th century.

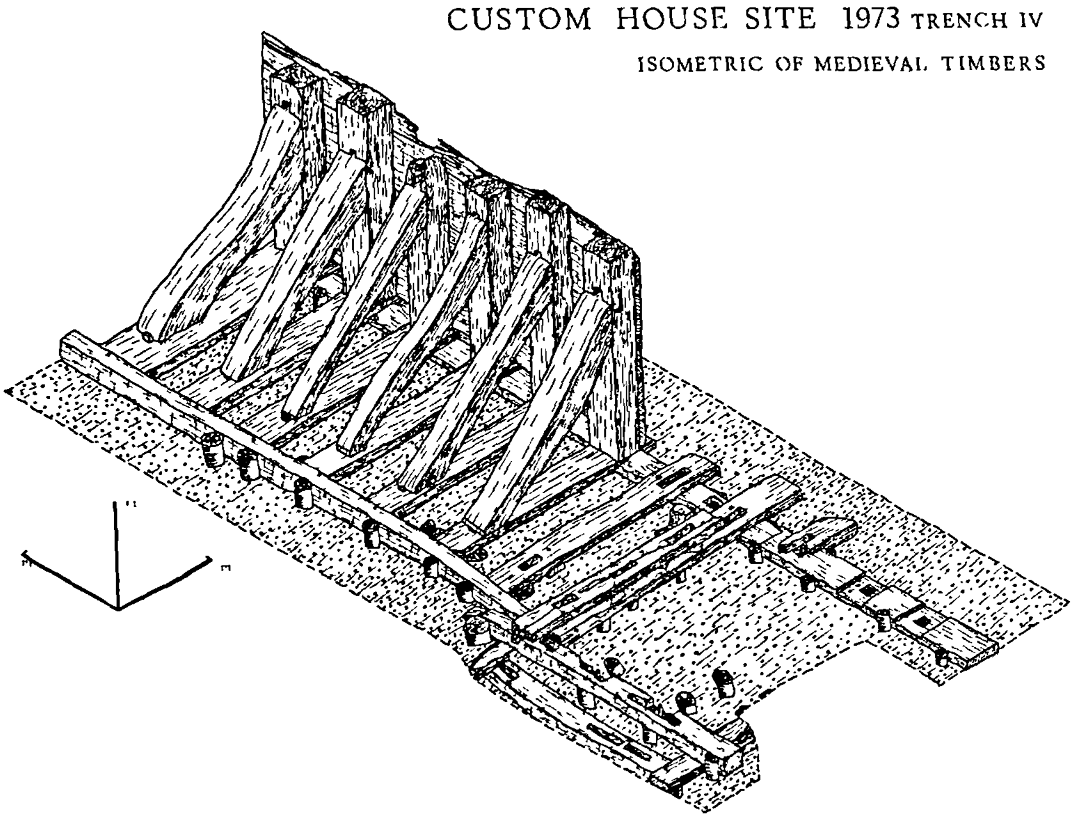



Figure 128. Fourteenth century timber quay from Custom House, from Tatton-Brown (1974)

Trig Lane (Milne and Milne 1982, 24 in Figure 121) has been mentioned above in Chapter 2. In summary, a series of waterfront structures (see Figure 129) were built between the mid 13th to mid 15th centuries all advancing southward into the river with the lowest working surfaces at approximately 2.0m OD but rising to 3.4m OD. This last one is considered significantly above HAT, which is calculated for this site at *c.* 2.0m OD on the basis of all structures. Finally, the stone river wall was built in c. 1440 to a height of 2.7m OD. Contemporary MHWNT was calculated at between 1.2 and 1.3m OD on the basis of timber rotting and patching (Milne and Milne 1982) and evidence of the carpentry and repair of the medieval timbers. Modern timbers are prone to rot at MHWNT due the timbers being diurnally submerged and exposed. Low water is estimated at a minimum of -1.2 OD with reference to the lowest part of the revetment, based on the necessity for access to build it. A boat (Blackfriars III) found sealed at -2.0m to -3.0 m OD is thought to indicate the maximum for 14th century low water, as the quay could not have functioned with a wreck partially exposed.

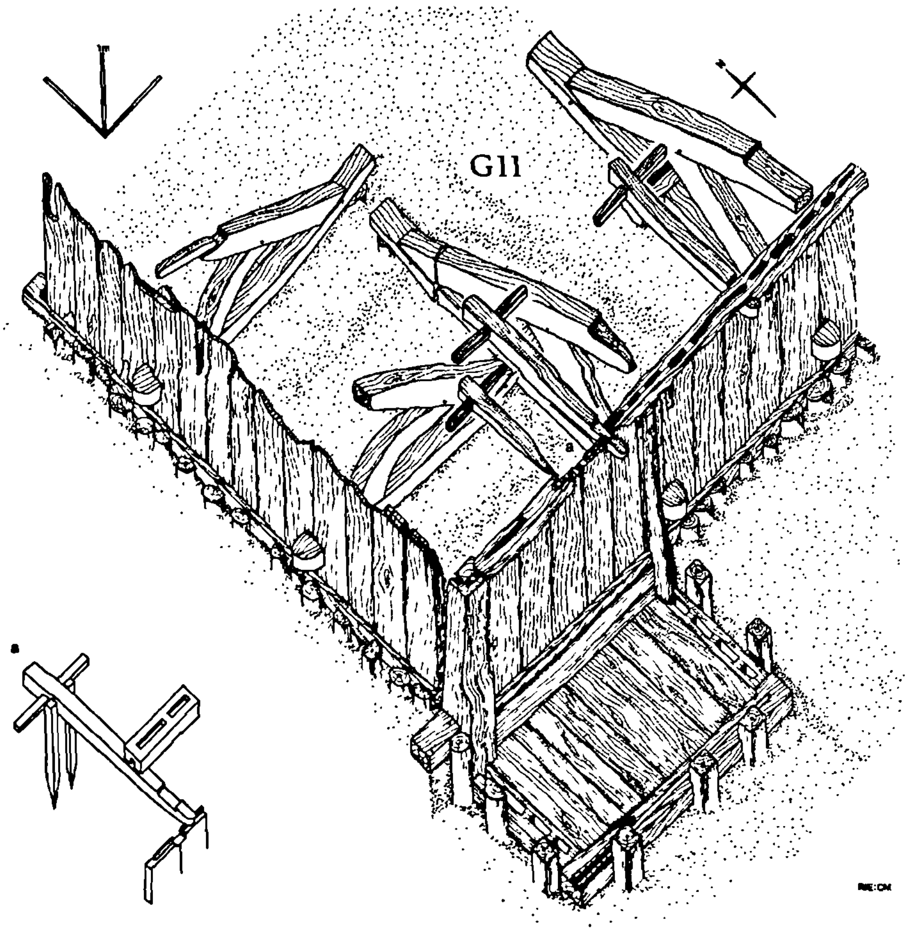



Figure 129. Timber revetment from Trig Lane, from Milne and Milne (1982)

Recent excavations at the footings of the new Millennium Bridge (25 in Figure 121) extended and re-opened the Trig Lane site (Ayre 2002) and also examined the Southwark waterfront in this period. The north bank timbers were better preserved and showed six revetments behind the 14th century wall. Unfortunately, none were preserved to the full height, but showed that river levels were above 1.1m OD during the 12th and 13th centuries. The baseplates were present from -0.85m OD to -1.1m OD. The revetments on the south side of the bridge were much more damaged and cannot easily be used. One piece of evidence available from the south bank is from Fennings Wharf where a series of 12th century revetments were constructed at the bridgehead, with baseplates present at approximately -0.8m OD. Again, unfortunately, they are very damaged and do not survive much above 0.2m OD (Watson et al. 2001, 70-71).

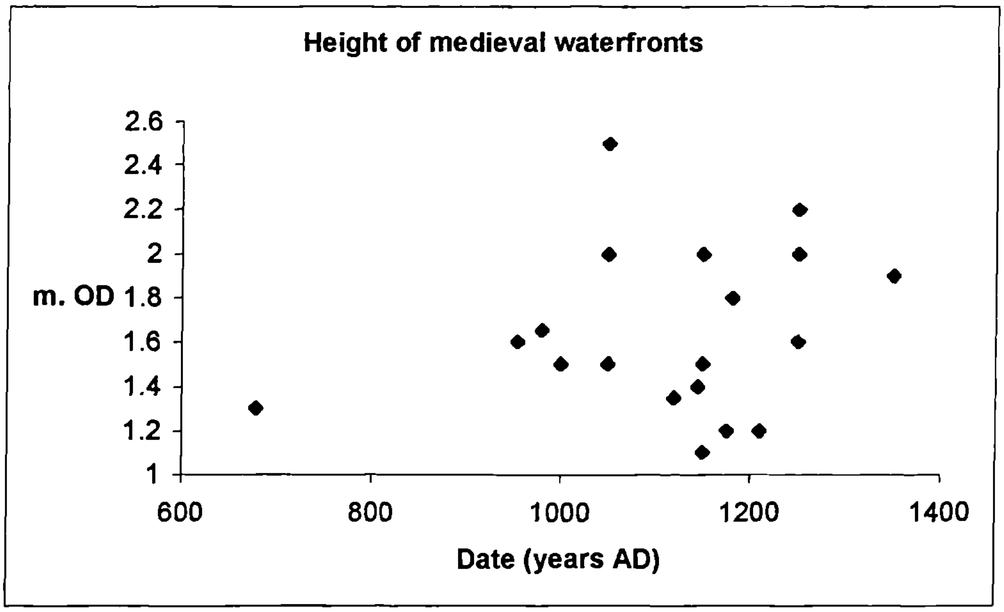



Figure 130. Graph of the altitudes recorded for the top of the medieval waterfronts

## Summary

The medieval data are more confused than the Roman evidence (see Figure 130), which is almost certainly related to the less centralized government in the medieval period and the necessarily *ad hoc* approach taken to the waterfront. Furthermore, the less robust quays may be more damaged than the excavators considered. The property division of this period makes it likely that the waterfront was not centrally administered as seems apparent for the Roman period. Therefore, extensions and reclamations happened randomly throughout the medieval period. Furthermore, changes in building techniques (Milne 1992) meant that timbers are less likely to yield tight dendro dates than the Roman ones which often still retain some bark, rather than being stripped even of sapwood. The discovery of the Seal House quay apparently below MHWST also confuses the issue, yet must have been built to serve a useful purpose, such as a beach market. Nevertheless, it seems apparent that there was a sharp rise in river level between the end of the Roman period and the Late Saxon, with relatively little change until well into the later medieval period. This is almost certainly related to increased tidal range than increased MSL as a result of the encroachment on the river of all the embankments and the effects of London Bridge.

| Waterfront | Mid 1st | Late 1st | Early 2nd | Mid 2nd | Late 2nd | Early 3rd | Mid 3rd | Base of River Wall | Late 7th | Late 10th | Mid 11th | Mid 12th | Mid 13th | Mid 14th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Toppings Wharf | 2.0 / 1.1 | | | | | | | | | | | | | |
| Borough High Street | 1.75 / ? | | | | | | | | | | | | | |
| Pudding Lane | 1.7 / 0 | 2 / 0 | | | | | | | | | | | | |
| Regis House | 2.5 / ? | 1.6/? | 1.38 / ? | | | | | | | | | | | |
| Billingsgate Buildings | 1.8 / 0.7 | 1.7 / 0 | 1.5 / -0.2 | 1.5 / -0.75 | | | | | | | | | | |
| Miles Lane (28 in Figure 114) | | 2.5 / 0 | | | | | | | | | | | | |
| Suffolk House | | 2.15 / 0.2 | 1.5 / -0.45 | | | | | | | | | | | |
| Courage's | | | | 0.5 / ? | | | | | | | | | | |
| Guys Channel | | | | | | | 1.0 / ? | | | | | | | |
| Baynards Castle (27 in Figure 114) | | | | 0.55 / 0.35 | | | | 1.0 | | | | | | |
| Swan Lane | | | | 1.1 / -0.5 | 0.7 / -1.0 | 0.6 / -1.0 | 0.6/ -1.0 | | | | 2.5 / ? | | | |
| New Fresh Wharf | | | | 1.3 / 0.6 | 1.2 / -1.0 | 0.5 / -1.5 | | 1.2 | | 1.6 / -0.34 | 2.0 / | | | |
| Seal House | | | | 1.1/? | 0.4/-1.75 | 0.5 / -1.5 | | | | | | 2.0 / -1.5 | 1.2 / ? | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Custom House | | | | 0.7 / -0.5 | 0.5 / -1.6 | 0.5 / -1.5 | ? / -1.0 | 0.7 | | | | | | 1.9 / -0.3 |
| Queenhithe | | | | | 0.0 /-1.8 | | | | | >1.45 / 0.5 | ? /-1.5 | 1.35 /-0.5 | | |
| Billingsgate lorry park | | | | | | 0.5 / -1.5 | 0 / -1.5 | | | | | | | |
| Billingsgate Market | | | | | | | | 0.4 | | | | | | |
| Three Quays House | | | | | | | | 0.0 | | | | | | |
| Northumberland Avenue | | | | | | | | | 1.3 / ? | | | | | |
| Thames Exchange | | | | | | | | | | 1.65 / -0.75 | 1.5 /-0.4 | 1.5/-0.75 | 2.2 / -1.7 | |
| Millennium Bridge (north) | | | | | | | | | | | | 1.1/-0.85 | 1.6 / -1.1 | |
| Fennings Wharf | | | | | | | | | | | | <0.2/ -0.8 | | |
| Trig Lane | | | | | | | | | | | | | 2.0 / -1.0 | >2 / -1.0 |

Table 31. Upper and lower limits of the London waterfront in metres OD, modified and expanded from Brigham (1990)

## 11.4 Summary

This examination of RSL change in the Thames has clarified a number of issues. Firstly, it has underlined the dangers of using the sequences from Tilbury as a type-site for the estuary, even though it is still unclear exactly what is causing the problem with the data. Secondly, it has made clear the possible advantages of using archaeological data to calculate past tidal range, which may be used in conventional MSL calculations.

In summary, it is proposed that a tripartite model of RSL change in the middle and inner Thames estuary is adopted, with less reliance on the Tilbury data. It is suggested that waterlogging of the floodplain began in the Late Devensian, leading to the formation of freshwater peats associated with relict channels in the area of the Isle of Dogs meander. Subsequent to this, RSL rises, but does not have any widespread impact in the middle and inner estuary until marine water is present some time before 5000 cal BC. This leads to rising watertables and the formation of peats, during slowed RSL rise from 5000 cal BC in the upstream reaches and 4000 cal BC downstream. Wood peat and subsequently alder carr is widespread throughout the estuary, including a rare *Taxus* community, with no evidence for a drop in RSL in this period. A transgressive overlap is seen in the downstream area from 1500 cal BC, and although there is evidence to suggest the continued formation of peat at Suffolk House until *c.* 150 cal BC, this is rather later than evidence nearby suggests. It is suggested that the increase in the rate of RSL rise is relatively rapid, progressing upstream into the City reaches by about 1000 cal BC. This transgression is still in operation today, but is constrained by sea and river defences. This model shows close similarities with other estuaries around the British south coast.

The archaeological evidence has proved useful, particularly for the historic period for which there is only one sea level index point. The data examined in 11.3 do not even form the complete corpus; there remain several sites which have not been written up and the archives of which are currently inaccessible. Nevertheless, it has been possible to reconstruct (within degrees of uncertainty of up to a few decimetres) the changing tidal amplitude of the Thames from the Roman to the high medieval period. Not only is this of importance for actually gauging where the river was, but the dataset have been used to calculate MSL for more ancient index points. Doing this is considered to be more accurate than using modern reference water levels on a river with a contemporary tidal range of 7.7m. This is in stark contrast to the predicted tidal range of less than four meters in the medieval period, and *c.* 2.25m in the Early Roman. Indeed, Figure 106 certainly appears more 'true' to expectations based on archaeological deposits than Figure 104, calculated with no calibration of tidal range. On the basis of this, Figures 104 and 106 are offered as graphs for discussion of RSL change in the inner Thames estuary.

If the use of historical tidal data is taken to its logical conclusion, one final point may be made with reference to crustal issues. This method indicates relatively higher altitudinal values for MSL throughout the Holocene than if modern reference water levels are used. This, of necessity, will affect previously calculated values of vertical crustal motion by reducing the magnitude of predicted change. In the case of the Thames estuary, the general difference shown using modern *versus* historical reference water levels is *c.* 4m, over a period when MSL has risen by approximately 14m. This potentially indicates that models of crustal motion/subsidence calculated using conventional sea level index points in the Thames could be reduced by *c.* 30%.

# *Chapter 12. Human response to environmental change*

## 12.1 Introduction

This chapter examines the evidence for human occupation in the study area with particular reference to adaptation to the effects of RSL change in the floodplain. This is done taking the periods of the initial Holocene transgression, subsequent estuary expansion and the second transgression as chronological divisions. Rather than tackle the entire chronology until the present day, it ends in the medieval period when people began to significantly affect the river through bridge building, embanking and reclamation. Following this, a summary model of the inter-relationship between people and environment in the inner estuary is proposed and discussed.

A general description of human activity in the Greater London region is outlined in Chapter 2 with further information in Chapter 11. This chapter aims to examine whether there is evidence for human response to changes in the estuary configuration including its geomorphology and ecology. This will be subsequently be discussed in the light of what is understood currently about the functional and belief-orientated cultural motivations behind the changes through this period. The term 'ritual' is used in this chapter to mean activities associated with belief systems of a non-functional or highly formalized type (i.e. Pader 1982; Richards and Thomas 1984; Bell 1992; Gibson 1998; Pendleton 2001), and not simply regular functional activity. Although this is a simplification (see Brück 1999a), it is a subject that will never be fully resolved.

General examination of cultural change and spatial patterning tends to be undertaken using available stratigraphic data, analysed within the sphere of theoretical and/or anthropological models. Rarely is environmental and topographic data given equal weight to theoretical models of human development, and environmental scientists have been loathe to be tarred with the brush of 'environmental determinism'. Nevertheless, in a river valley environment, environmental change is likely to have significant impacts upon human use of the area and common sense would suggest that when rivers change course or rise, relative to the land, several courses are open to the human population. This naturally depends on what type of society exists within the environment, but in the case of the Holocene Thames, a subsistence economy is succeeded by a developing community with elaborate ritual elements, finally developing into an urbanized commercial population. Starting from this ground, the most likely premise is that the earlier more mobile groups who were less tied down with possessions such as fields and dwellings would respond to environmental change by simply changing their areas of resource acquisition. As the population in the Lower Thames developed, it seems likely that more effort would be expended on attempting to counter the effects of environmental change in order to maintain settlements and also the order of life, society and individual power that had been achieved. This simple hypothesis is examined in the following sections.

## 12.2 The Early Holocene transgression

This phase equates to the Late Upper Palaeolithic and Mesolithic, including part of the Neolithic in the downstream stretch of the study area (Wennington to Silvertown; 1 and 2 on Figure 131), until *c.* 3800 cal BC, and *c.* 4800 cal BC in the upstream zone (Westminster (3 on Figure 131) to Silvertown). There is limited evidence for Late Upper Palaeolithic activity anywhere in the Thames floodplain. Although many handaxes have been recovered from the river, their origin cannot be proven. There is evidence of human activity in the Colne floodplain at the site of Three Ways Wharf (Lewis 1991, 4 on Figure 131), but this tributary would only be influenced by the Thames in terms of river gradient at this date. A key issue is that Upper Palaeolithic sites will be buried at depth on the Pleistocene gravel or between the gravel and Langley silts. These deposits are not always penetrated by all archaeologists, who misguidedly feel that no archaeology will be present at such depth (see Merriman 1992). Furthermore, the Thames has migrated south across the floodplain during the Devensian, eroding much of the riparian zone. The river sides are key locations for Palaeolithic groups as valleys are generally considered to be migratory paths along which early hunter gatherer groups would have moved (Wymer 1999), possibly following herds of game; reindeer in the colder periods and warm-adapted fauna subsequently. Furthermore, rivers are considered to be crucial to hunter-gatherer strategy by expanding the available territory owing to the increased speed of movement possible through river transport (Mellars, 1978). For the people of the Thames, this would have increased their 'catchment' out towards Europe and could have been used to maintain a wide network of social links (Mellars 1978).

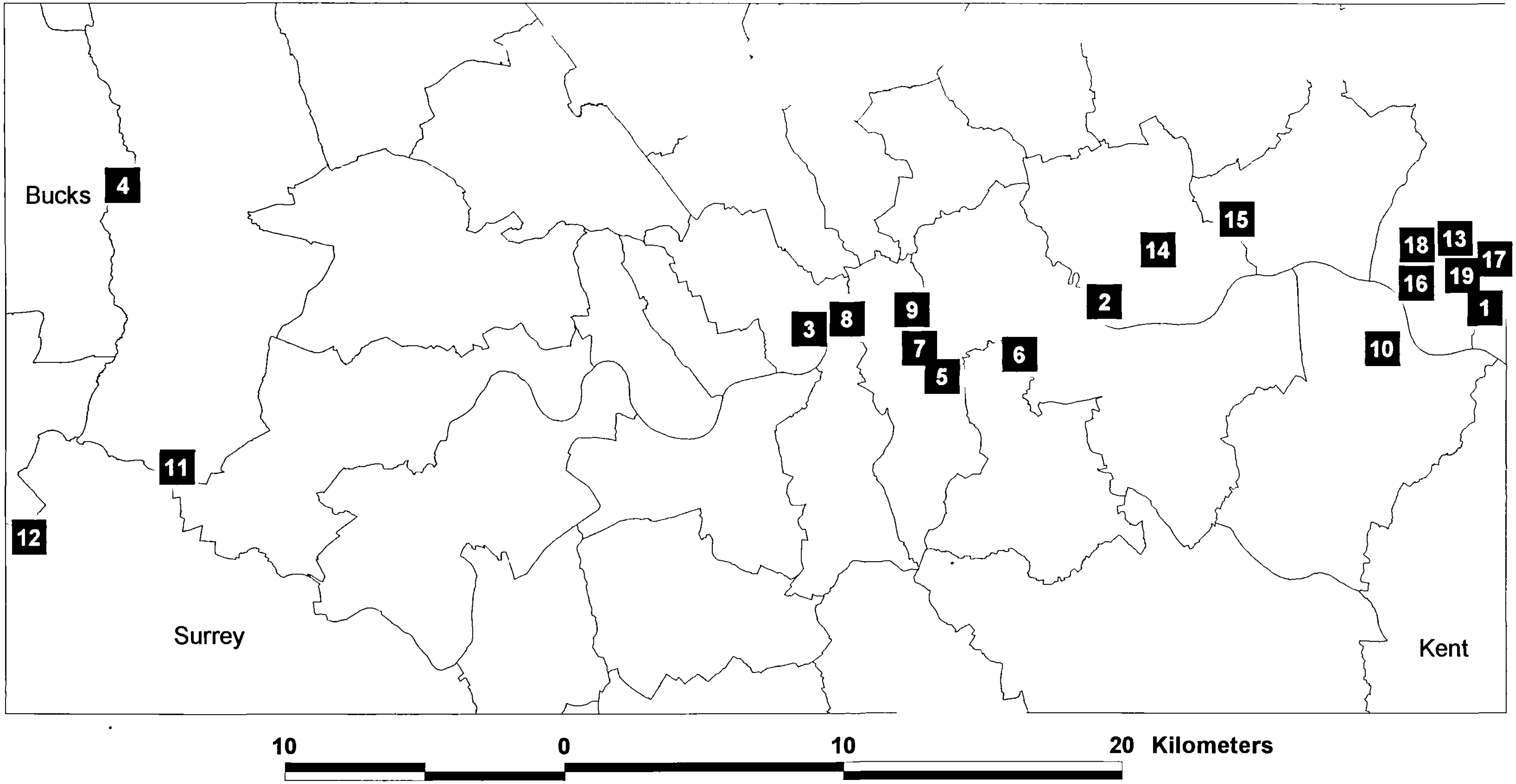



Figure 131. Map of sites discussed under Early Holocene transgression

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Wennington | 5425 | 8025 |
| 2 | Silvertown urban village | 4050 | 8035 |
| 3 | Westminster | 3022 | 7962 |
| 4 | Three Ways Wharf | 0525 | 8458 |
| 5 | B&Q | 3430 | 7789 |
| 6 | Masthouse Terrace | 3750 | 7850 |
| 7 | Marlborough Grove | 3420 | 7810 |
| 8 | Waterloo | 3088 | 7974 |
| 9 | Horselydown | 3360 | 8000 |
| 10 | Erith spine road | 5060 | 7880 |
| 11 | Heathrow | 0727 | 7450 |
| 12 | Runnymede Bridge | 0157 | 7199 |
| 13 | Rainham | 5280 | 8200 |
| 14 | Woolwich Manor Way | 4249 | 8220 |
| 15 | Movers Lane | 4530 | 8330 |
| 16 | Rainham Brookway | 5258 | 8180 |
| 17 | Launders Lane | 5418 | 8179 |
| 18 | Rainham CTRL trace site | 5225 | 8175 |
| 19 | Southall Farm | 5325 | 8160 |

Table 32. Sites shown on Figure 131

### Upstream (c. 10,000-4800 cal BC)

Early Mesolithic activity is also relatively sparse. One early site that owes something to the development of the Thames is the B&Q warehouse on the Old Kent Road (Rogers 1991, 5 on Figure 131). The Early Holocene Thames gradually abandoned a series of braided channels. Various things happened to these; some silted up, for instance at Silvertown and probably at Masthouse Terrace (6 on Figure 131). Another, which cuts across Bermondsey, is thought to have become a lake. The B&Q site consists of an Early Mesolithic home base where a range of activities occurred, including tool manufacture, food and hide preparation. There may also have been shelters. A contemporary site was found close by at Marlborough Grove (7 on Figure 131), where flint nodules were cached prior to working. The site is located well above contemporary river levels at *c.* 1.0m OD, on the edge of a sand terrace, but will almost certainly have been selected because of the advantages associated with a lake, such as fresh water and food. Similar tools have also been recovered from Waterloo (Sidell et al. 2002, 8 on Figure 131). The site is not as well defined; it is slightly lower, at 0.8m OD, still above the contemporary freshwater Thames, but associated with a channel draining into it. Several Late Mesolithic flint scatters have been found on the Horselydown sand eyot (Ridgeway and Meddens 2001; Bates and

Whittaker, in press, 9 on Figure 131), indicating that people used this island, however, even at *c.* 0.3m OD, this is likely to have been above the river or tide.

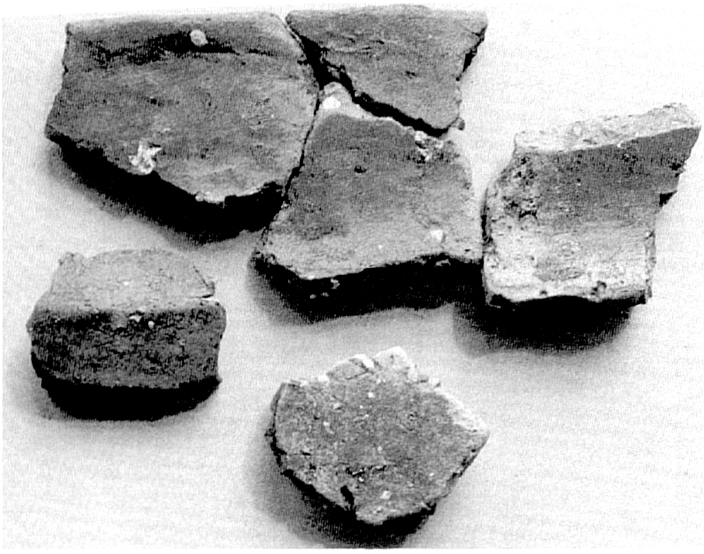
Generally, during this period of transgression, people left few traces but the river and riverside was certainly used, for there are many discarded tools in the floodplain and more particularly, dredged from the river (Lacaille 1961; Cotton and Wood 1996, Cotton 1999; Lewis 2000a). These include many axes, adzes (including the so-called '*Thames picks'*, Field 1989), bone and antler points and mattocks all found in much greater profusion than on land. It may simply be a recovery bias, however, it is as likely that the traces of material simply indicate the centrality of the river to Mesolithic life in the Lower Thames valley. There is a school of thought that believes many of the stone tools were ritually deposited in the river, particularly the unusual Thames picks (Field 1989; Cotton and Wood 1996). Although it will not be possible to confirm ritual deposition and what inherent ideology was implied, it is possible to speculate. Watery places have been the focus of ritual deposition for millennia (Richards 1996; Bradley 2000, chapter 4), possibly because of the power and endurance of natural forces (Tilley 1991, 1994; Bradley 2000, 8) and the Thames does not appear to be an exception. Common reasons for the deposition of objects are thought to be placatory, supplicatory or demonstrations of personal wealth and power; the *'flamboyant discard'* of Bradley (1990). This latter form tends to be associated with the metal-based periods.

0.3m in length
Figure 132. 'Thames pick,' (Museum of London collections)

A possibility with the Thames Mesolithic finds is that if there is a 'ritual' as well as functional component to the assemblage, the offerings are more likely to be votive than displays of wealth (Field 1989). The more complex social systems leading to the acquisition of wealth are unlikely to have been constructed in the Mesolithic and therefore, if there is a ritual element of deposition at this time, other reasons must be sought. This could include supplication against natural forces. A key point made by Bradley (2000, 53) is that different types of offering may be made in different places. He links this with the type of 'deity' to whom the offering is being made; i.e. in classical Greece, offerings to Poseidon (god of the sea) were made in watery places whilst Demeter (goddess of soils and fertility) received her offerings in valleys (Jost 1994). It must be considered a possibility that votive objects in the Thames are in some way directly associated with the river itself (himself/herself?), and in a period of rapidly rising river levels and the introduction of the tidal regime in the upstream zone, this may well be significant.

## Downstream (*c.* 10,000-3800 cal BC)

The Late Mesolithic site on the Erith Spine road (Bennell 1998, 10 on Figure 131) indicates tools were manufactured on the foreshore itself, presumably in order to keep a nearby camp free of the thousands of pieces of sharp debitage. In this location, the peats did not begin expanding until into the fourth millennium cal BC and the Erith site shows a continuity of occupation in the floodplain by the presence of Grimston Lyle Hills pottery found (Figure 133) associated with charcoal giving a date of *c.* 3900 cal BC; a very early date for ceramics in London. A substantial peat bed, indicating the onset of a phase of wetland expansion, sealed the foreshore sediment. There is no evidence for subsequent occupation in the area until the Middle Bronze Age, when the wetlands begin to contract.



Rim diameter calculated at 280mm

Figure 133. Grimston Lyle Hills pottery from Erith, from Bennell (1998)

Moving into the Neolithic, central London has often been considered remarkably devoid of much Neolithic activity (Lewis 2000b, 65), particularly in the early period. The depth of overburden in the floodplain may influence this. However, it is noteworthy that Heathrow (11 on Figure 131), the other main prehistoric 'centre' within London, also has practically no Early Neolithic finds. The monuments fringing west London date to the later part of the Early Neolithic (Cotton 2000). Runnymede Bridge (12 on Figure 131), is arguably the most important site of this date (Needham and Trott 1987; Needham 2001), but is outside the estuary and indeed Greater London. However, Rainham (13 on Figure 131) is a focus of activity in the Early Neolithic. Recent fieldwork has extended this along the line the A13 road (Bates and Whittaker in press) of the gravel terrace edge towards north Woolwich. Early Neolithic blades, flakes and a leaf arrowhead were found with food waste and Mildenhall Ware at Woolwich Manor Way (Gifford and Partners 2001a, 14 on Figure 131), with more artefactual material and cut features further to the east at Movers Lane (Gifford and Partners 2001b, 15 on Figure 131) were found.

This area, apparently centred on Rainham is particularly important because it contains a range of activity types and also because it crosses the physiographic boundary between the terrace and the floodplain. The Early Neolithic site at Brookway (16 on Figure 131) indicates some form of settlement at the edge of the terrace (Meddens 1996;

Lewis 2000b, 68), subsequently overlain by the peat. This is close to the contemporary Launders Lane (17 on Figure 131) enclosure back on the gravel (Greenwood 1982). A new site on Rainham Marsh in the CTRL trace (18 on Figure 131) consists of a flint scatter on a palaeo-surface sealed directly beneath a substantial peat a few hundred metres away from the Brookway site, but has yet to be fully excavated. Another enclosure has recently been found at Southall Farm (19 on Figure 131) a few hundred metres to the west of Launders Lane. It is as yet unpublished, but appears to be of Early Neolithic date, with a very substantial pit alignment and placed deposits in the ditch terminals. There is some subsequent Bronze Age activity on the site.

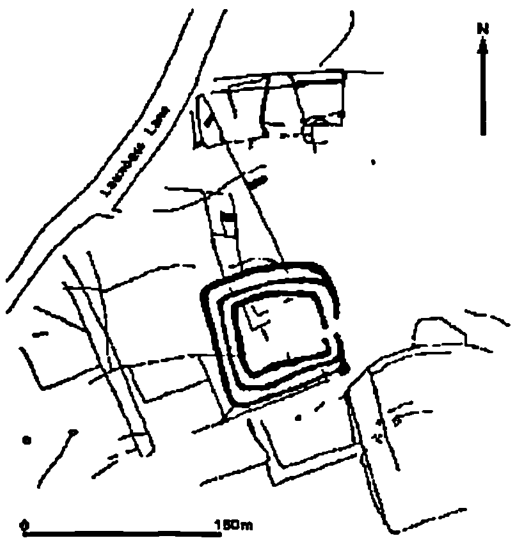



Figure 134. Launders Lane Neolithic enclosure, from Greenwood (1982)

A pattern that seems to be emerging is of a hiatus in occupation from the Early Neolithic until the Middle Bronze Age in Rainham, Erith and also north Woolwich, where Early Neolithic features were recently recovered on the edge of the gravel terrace with Middle Bronze Age trackways just off into the floodplain (Whittaker 2001). It is likely that mobility persists into the 4th millennium (Barrett 1994, 144), in tandem with increasing sedentism (*sensu* Whittle 1997), so it is not surprising to find few Early Neolithic settlement sites. Furthermore, there is an argument that this period was one of monument building rather than sedentism (J. Thomas 1999, 222). Nevertheless, the focus of activity in the downstream zone is perhaps important. It is tempting to consider this in the light of the need for the Mesolithic communities to restrict their migration routes in view of rising coastal waters and indeed the breaching of the straits of Dover and the submergence of the North Sea from *c.* 6500 cal BC. This may have led to a focus further upstream from previously used areas. An additional piece of evidence might be the presence of monuments in West London slightly after the earlier activity downstream, and only later the development of more significant settlements (Barrett et al. 2000a; Lewis 2000b; Crockett 2001).

## 12.3 Wetland Expansion

This commences upstream in the Mesolithic from *c.* 4800 cal BC in upstream areas and after *c.* 3800 in the downstream zone. It is a period when the peat beds and marshes extended significantly into the floodplain, away from the terrace edges, with the river constrained within a narrow channel.

### Upstream (c. 4800-100 cal BC)

There is little archaeological evidence for the early part of this period; modern central London records less archaeology for Late Mesolithic and Early Neolithic periods than downstream. There is no firm evidence for anything more than the presence of transitory groups, even on the stable terraces adjacent to the floodplain. Once again, the majority of data comes out of the river in the form of stone tools (Adkins and Jackson 1978). The interpretation of these is problematic; there are suggestions that they were lost in dryland environments such as the recently exposed forests at Purfleet and Erith (1 and 2 on Figure 136, Wilkinson and Murphy 1995, 98; Seel 2000, 2001), and certainly a few have been found at Purfleet. However, there is a possible ritual explanation; 'burial' in the river (Thomas 1991, chapter 4). Many of the tools have traveled long distances from the origin of the stone, such as Cornwall, Ireland and France (Bradley 1990; Lewis 2000a, 74) and would therefore have been precious items (see Figure 135) and difficult to replace (Cotton 2000). Furthermore, many of them are obviously non-functional, such as the impressive collections of polished axes accumulated by antiquarians. It seems likely that both explanations have some merit.

180mm in length

Figure 135. Jadeite axe from the Thames, (Museum of London collections)

The earliest information from this period in the upstream zone comes the Fort Street (on the boundary between upstream and downstream of this study area) timber structure (Crockett et al. 2002, 3 on Figure 136). There is some discrepancy in the dating, but it seems likely that one structure was constructed around 3100 cal BC, taking the form of either a platform or walkway with a subsequent Bronze Age phase of activity leaving a small assemblage of post-Deverel-Rimbury pottery. Also at issue is the dating in relation to the peat below the structure, which dates to *c.*2800 cal BC. The exact dating is not a great issue - what is clear is that just *subsequent* to the onset of peat formation, a structure was built in a slightly raised area within the marsh. It may be that this was an immediate response to waterlogging in an area subsequently abandoned until the mid Bronze Age. The nature of activity in both periods is ephemeral and suggests that although the floodplain was traversed, there was no attempt to occupy it in a more permanent manner. By this period, settlement evidence is still extremely restricted.

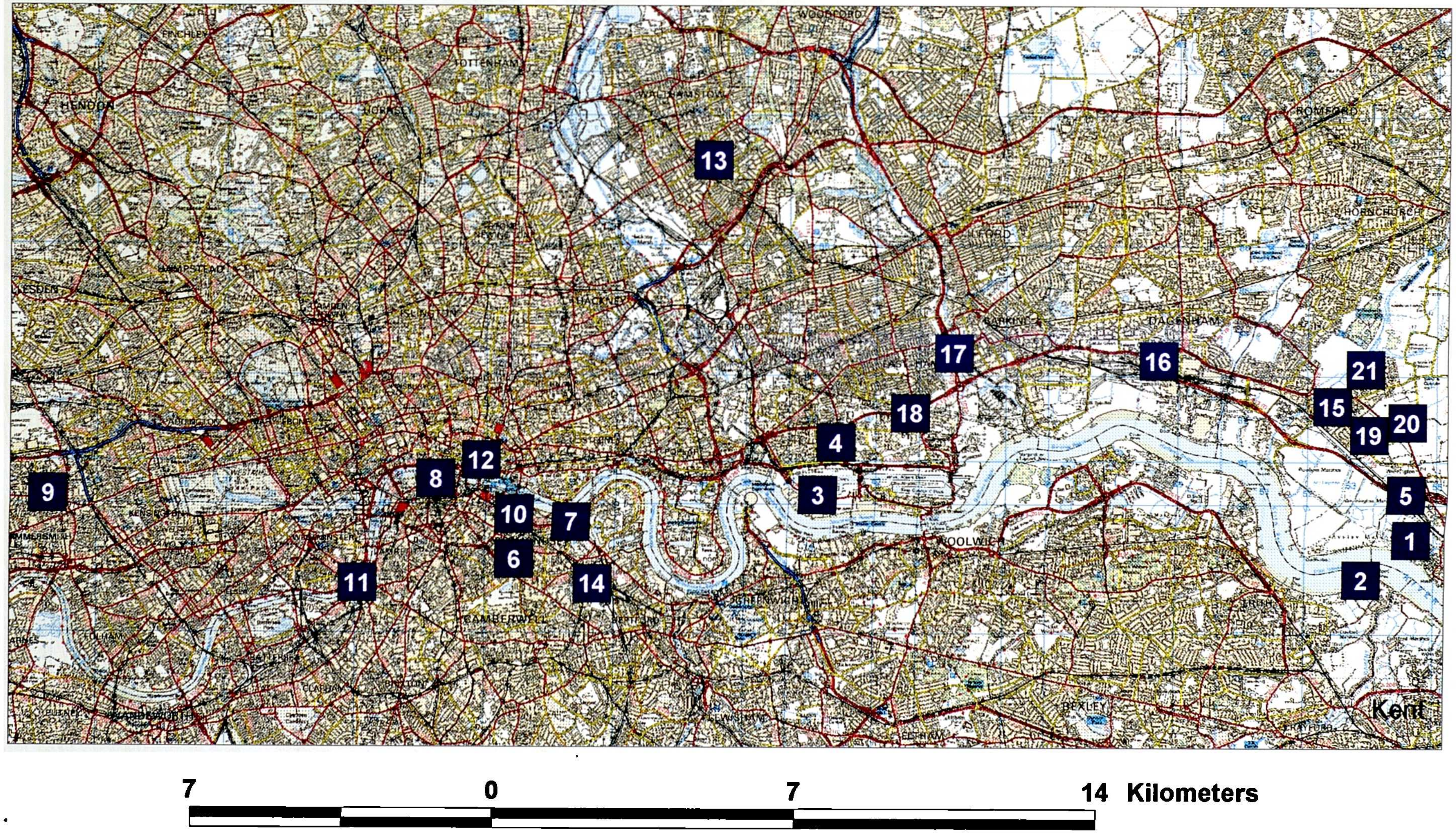



Figure 136. Map of sites mentioned Chapter 12.3

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Purfleet | 5445 | 7891 |
| 2 | Erith forest | 5330 | 7820 |
| 3 | Fort Street | 4077 | 8020 |
| 4 | Royal docks school | 4130 | 8110 |
| 5 | Wennington | 5425 | 8025 |
| 6 | Bricklayers Arms | 3380 | 7850 |
| 7 | Culling Road | 3510 | 7940 |
| 8 | Hopton Street | 3182 | 8045 |
| 9 | Fennings Wharf | 2281 | 8037 |
| 10 | Phoenix Wharf | 3379 | 7965 |
| 11 | Vauxhall | 3020 | 7800 |
| 12 | Suffolk House | 3271 | 8077 |
| 13 | Atlas Wharf | 3812 | 8792 |
| 14 | Bramcote Grove | 3515 | 7805 |
| 15 | Rainham | 5280 | 8200 |
| 16 | Dagenham | 4860 | 8330 |
| 17 | Barking | 4380 | 8350 |
| 18 | Beckton | 4270 | 8200 |
| 19 | Southall Farm | 5325 | 8160 |
| 20 | Launders Lane | 5418 | 8179 |
| 21 | South Homchurch | 5325 | 8300 |

Table 33. List of sites showη on Figure 136

The site at the Royal Docks School, Custom House (4 on Figure 136) provides similar information, with a small area of higher ground in the floodplain used for cooking and tool manufacture but with no evidence for structures; rather similar to the Mesolithic camp on the Old Kent road. Again, this is confirmation that the floodplain is being used, but not being settled. There is no evidence for the way of life behind the types of evidence that has been found, but a possibility must be that this camp, and possibly the Neolithic structure at Fort Street, is associated with people grazing flocks or pursuing game on the marsh. A key issue is the ecology of the marsh at any point; grazing flocks of sheep or cattle would not be practical if the marsh was wooded and this appears to be case just above the base of the peat. Woodland would have contained game such as *Cervus elaphus* and *Bos primigenius* (the latter still present in the Early Bronze Age). Bell has noted that these species would have been useful for maintaining open areas at woodland margins, and may have been encouraged rather than randomly hunted (Bell 1992). The subsequent alder carr and salt marsh would have been more practical for grazing livestock. The question then is when did the wood peat become replaced by the alder carr and then salt marsh? The dendrochronology date from Wennington (5 on Figure 136) indicates that the peat was still wood-based in *c.* 2100 cal BC whilst by *c.* 1500 cal BC the majority of the wetlands, (inner-estuary wide) are mainly alder carr and it is likely to be between these dates that the marshes first became useful for grazing, which would have facilitated a more sedentary lifestyle or conversely, have led to the loss of good hunting grounds.

Returning to the Bermondsey Lake, it was also used in the Neolithic, with several timber platforms and axes deposited in the peats at the edge of the lake basin at the Bricklayers Arms (Jones 1991; Merriman 1992, 6 on Figure 136). Once again, there are no signs of dwellings and it can only be concluded that the area, like the northern floodplain, was used but not settled and that material has accumulated in the more accessible areas, such as sand eyot or lake margin. It is possible that the Bricklayers Arms is primarily a belief-orientated site. The presence of a decorative and non-functional axe adjacent to a lake with several platforms indicates the possibility of 'placed deposits' (Thomas 1996, 177; Bradley 2000, 118). Furthermore, articulated horse bones were also recovered; the presence of axes and bones of this date found together has been considered to be a form of placed offering (Bradley 2000, 118).

Thomas and Bradley have remarked on the preponderance of axes coming from the Thames in presumed 'ritual' contexts and make the wider point that rivers are a common ritual deposition ground in the British Neolithic with axes and other polished stone tools common offerings to come out of rivers. In fact, they are more often found in rivers than on dry land; for instance 900 have been collected from Irish rivers compared with only 68 from archaeological 'sites' (Cooney and Mandal 1998, 38). Although a degree of grinding and polishing improves the cutting edge, the axes recovered from the Thames have been excessively modified (Bradley and Edmonds 1993, 49). In addition to the axes, the London Thames also has a larger amount of Neolithic maceheads than in much of Britain (Bradley 2000, 118).

*c.* 150mm in length

Figure 137. Axe and macehead from the Thames, from Merriman (1990)

A Late Neolithic site was found at Culling Road in Bermondsey (Sidell et al. 2000, 93, 7 on Figure 136), approximately a kilometre away from the Bricklayers Arms, with Peterborough Ware and blades present on another further sand eyot at approximately 1.0m OD. No traces of structures were found, indicating sporadic use of the area. Again, the site is above the contemporary river but shows consistent preference for eyot locations within the floodplain (see Brown 1997).

Early Bronze Age material in the upstream stretch is also rare, but several sites indicate a presence. The first of these is Hopton Street (Ridgeway 1999, 8 on Figure 136), mentioned above in Chapter 2. It is significant in being the first hard evidence for farming in the floodplain, dating to *c.* 2000 cal BC (or shortly thereafter) on the basis of the unusual Beaker bowl (Figure 138) placed as a votive offering prior to taking the land into cultivation. No direct evidence for settlement was found on site, but it is assumed that the fields would not be too far from dwellings. The use of the floodplain for farming has previously been considered unusual, but the date of this site is well into the period of estuary contraction in the upstream zone. This is likely to have been a time of increased land availability, making Hopton Street less marginal than has previously been considered.


Scale = 100mm

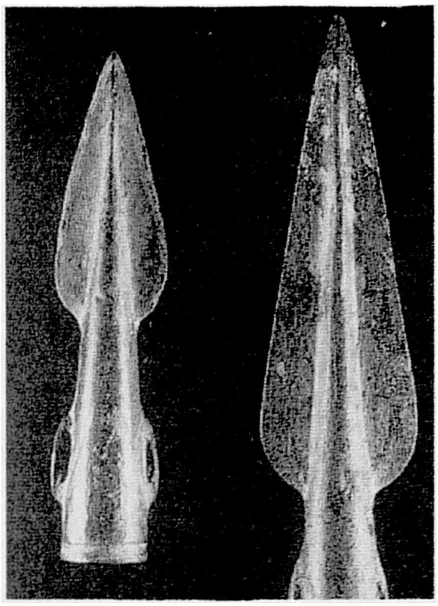
Figure 138. The Beaker bowl from Hopton Street, from Cowan (2000)

The next site in this zone is the Fennings Wharf barrow (Sidell et al. 2002, 9 on Figure 136), located on a promontory overlooking the Thames. The burials date to between *c.*1800-1500 cal BC (Bayliss 2002), and its position must have been selected with reference to the Thames. It is not on particularly high ground (1.0m OD), as is more usual with barrows (Greenwell 1877, 8; Darvill 1990, 79), but rather jutting out into the river and therefore this would seem to have influenced the position. The Bronze Age is a time of increased burial associated with the river (Bradley and Gordon 1988) and so the Fennings barrow is likely to form part of this tradition.

The next site in date is the Phoenix Wharf burnt mound (Bowsher 1990, 10 on Figure 136) close to Tower Bridge. As yet, there are no conclusive interpretations regarding the use of burnt mounds, but suggestions include cooking pits and shamanic sweat lodges (Barfield and Hodder 1987; O'Drisceoil 1988, Buckley 1991; Gibson 1998). However, they are generally associated with water, and considered to have a ritual association. In this case, the term *ritual* may simply be mis-applied in the case of an as-yet unidentified form of archaeological feature (see Bahn 1989). Nevertheless, this period is one of increased non-functional activities occurring in the floodplain, exemplified by the sheer volume of metalwork deposited in the river from this time; the collection of mid-late Bronze Age weapons from the Thames equals anything in northern Europe, which is indeed where much of it derives from (Bradley 1990, 2000, 54). Furthermore, different classes of find come from different stretches of the river (Needham and Burgess 1980) indicating a high degree of selection uneradicated by post-depositional processes.

An example of what may prove to be a key location is the Vauxhall foreshore (Haughey 1999; Milne 2002, 11 on Figure 136), just on the western extremity of the current study area. A mid Bronze Age timber structure here is in a central position relative to many of the metal finds and the two spearheads found in the ground here indicate it may have been a platform used for sacrificing artefacts. Although at this date, the wetlands still appear to have been forming, (as indicated at Suffolk House, 12 on Figure 136), diatom evidence (Cameron, pers. comm.) shows that the tidal head was well upstream of Vauxhall, with diatom taxa such as *Paralia sulcata* and *Cyclotella striata* recovered. There are similarities to Flag Fen (Pryor 1991, 1992, 2001); obviously Vauxhall is on a much smaller scale, but comparison is valid with a timber structure in a liminal zone used to offer artefacts onto dry land and into water.

One interpretation is that the structure may have led to a small island or bar formed at the confluence of the Thames and two branches of both the Effra and Tyburn. The structure seems too large to served simply as a walkway, being 4m wide, and it may, therefore, have been used to move carts or large numbers of people. Indeed this width bears some comparison with some of the larger post alignments at Flag Fen (Pryor 2001). The construction would have been extremely time-consuming and such an investment of effort is unlikely to have been for a trivial reason, although this does not necessarily mean a ritual structure. One possibility is that it was used to get to a place of burial, with bodies placed on an island and subsequently taken by the tide, for which there is some evidence at Eton rowing lake (not tidal, but bodies placed on an in-channel island, Allen et al. 1997). It is a possibility that if this were the case, the structure may simply have been below MHWST and any offerings left on it could be floated off by the tide. Given the relatively few known burials from the period (Fennings Wharf being a very rare case) in contrast with the number of skulls from the Thames (over 300, Bradley and Gordon 1988), such a practice is not entirely out of the question. Excarnation certainly seems to have been practiced in Britain at this date (Bradley 1990, 161; Thomas 1990) and the use of the Thames in this sort of ritual seems likely.



The larger is 150mm in length

Figure 139. The side-looped spearheads from Vauxhall (Museum of London collections).

Additional floodplain archaeology of the mid Bronze Age comes from Atlas Wharf on the Isle of Dogs (Lakin 1999, 13 on Figure 136) where several platforms were built adjacent to a channel cutting through a substantial peat bed, apparently to stabilize what may have been the contemporary waterfront. Bramcote Grove has been mentioned above (Thomas and Rackham 1996, 14 on Figure 136), where the Bermondsey Lake basin has filled entirely with peat by the time the trackway was constructed. No end was found but it has been assumed that it is going from the gravel terrace to the south over to the eyot in the northwest. No prior settlement has been found from this site, but it would have been unoccupiable before the lake silted up (there is no evidence for a crannog). Slightly after this date, a substantial network of coaxial fields is created close by, centred on Phoenix Wharf (Drummond-Murray et al. 1994; Bates and Minkin 1999). The relationship of this to the earlier (by approximately 500 years) system at Hopton Street is unclear. The new fields are on slightly lower lying ground (*c.* 0.3m OD) and there is tentative evidence for manuring on the later sites (Bates and Minkin 1999; Elsden 2001). It is possible that there are two phases with a hiatus between, or that increasing land-take required expansion or indeed that exhaustion of the soils in the Hopton street area necessitated the move. Furthermore, the recent discovery (May 2002) of a Beaker associated with a trackway of the same date as the later field systems may indicate a practice of curating Beakers (Bradley 2002, 58), which could then mean that there is no firm date for the Hopton Street ardmarks.

The development of these systems at this time fits within a wider pattern within the Thames (Yates 1999, 2001) and indeed southern Britain as a whole, where it is becoming clear that the so-called 'Neolithic Revolution' of wide-scale farming did not take place until the Bronze Age (Yates 2001; Bradley 2001). Additionally, it is becoming apparent that very little in the way of Early Bronze Age 'settlement' can be found in southern England at all (Brück 1999b).

The Southwark fields are all sealed by estuarine silts and it seems that this occurred only a few hundred years after they were taken into cultivation, *c.* 1100 cal BC, on the basis of dated sequences from slightly further upstream (Sidell et al. 2000, 110). When the fields were submerged they must have become redundant because of the brackish water. This sees the end of substantial prehistoric use of the floodplain, with only a few traces of activity, such as the re-use of the Fennings barrow *c.* 800 cal BC. Although the deposits at Suffolk House indicate that marsh continues to develop on the valley sides until the Late Iron Age, the deposits in Southwark make it clear that the estuary re-expands at a relatively rapid rate (calculated at *c.* 5m/year, Sidell et al. 2000, 109) by the beginning of the first millennium BC, and this date may therefore be a more accurate end for the phase of wetland expansion.

### Downstream (*c.* 3800-1500 cal BC)

The development of the Rainham area (15 on Figure 136) has been noted above. However, after the initial distribution of Early Neolithic flint scatters and few settlements, there is practically no activity until the Middle Bronze Age with the exception of the appearance of the Dagenham idol (Figure 140), dating to 2460-2110 cal BC (OxA 1721, 3800±70 BP) (Wright 1923; Coles 1990). Prior to radiocarbon dating, the idol had been interpreted as part of pre-Celtic religion on the basis of the pinewood it is made from (Piggott and Allen 1970), but this was debunked (Godwin 1975) on the basis of late survival of pine, which has been noted in the study area. Coles has linked the idol to Scandinavian iconography, with a very tentative comparison with the deity Odin (Coles

1990). What is clear is that the British and Irish idols are associated with estuaries and coasts but not inland sites. Whether this relates to a specific cult or belief system is unclear, but it places the London wetlands into a wider British context. This is further parallelelled in mainland Europe, where a series of wooden images have also been found in the wetlands (van der Sanden and Capelle 2000), although there are only two older than the Dagenham idol; the Mesolithic Dutch Willemstad figurine and the Neolithic Somerset god-dolly (Coles 1998; van der Sanden and Capelle 2000).

The postulation of no activity until the mid Bronze Age holds true for all the sites where there is activity before the wetlands begin to expand. The timing may be co-incidental, but concurrent with the marsh expansion there is less evidence for human activity in the downstream zone than before the wetlands developed. This could be a factor of recovery, but seems unlikely as generally peat beds are tackled with enthusiasm by archaeologists and the deposits underneath are excavated less often. Interestingly, there is evidence for activity during wetland expansion within the floodplain further downstream in Essex, for instance at Purfleet (Wilkinson and Murphy 1995).

0.5m in height

Figure 140. The Dagenham idol, from Merriman (1990)

It is only with the advent of the Middle Bronze Age that substantial evidence for activity is once more present in the downstream stretch. This is in the form of the trackways from Rainham, Dagenham, Barking, Beckton (16, 17 and 18 on Figure 136), North Woolwich and Erith. These have been mentioned above and are discussed elsewhere (Meddens and Beasley 1990; Meddens and Sidell 1995; Meddens 1996; Bennell 1998). The importance is that they are all generally contemporary (as can best be said within radiocarbon ranges) and similar in construction, almost exclusively made with unmanaged alder roundwood (Seel 1997, 2001). Furthermore, they all tend to be close to the top of an alder carr peat, rather than in the preceding wood peat. It must be considered likely that these trackways (with the exception of Erith) are serving a substantial community based on the gravel terrace along the line of the modern A13 road from Rainham (at least) all the way to Silvertown where there is a phase of Middle Bronze Age activity on the site of the earlier Neolithic trackway (Crockett et al. 2002). Interestingly, the western Essex floodplain is remarkably devoid of mid Bronze Age activity (Brown 1996).

The recent excavations along the A13 have found traces of contemporary field systems and settlement in Barking and Beckton, whilst recent work at Southall Farm (19 on Figure 136) on the terrace in Rainham has also produced Bronze Age activity in the form of a series of burnt mounds along a stream. This site is a few hundred metres away from the Late Bronze Age cremation cemetery close to the Launders Lane enclosure (Greenwood 1982 and 20 on Figure 136). Yates (2001) has identified a series of field systems here of mid-Late Bronze Age date, and links these with another group slightly downstream. A recent discovery has been a Late Bronze Age ringwork with associated fields at South Hornchurch (21 on Figure 136), on the terrace edge between Rainham and Dagenham (Guttman and Last 2000). It seems not unreasonable to link the activity in the wet with the occupation on the dryland, but the problem is establishing exactly what the wetlands were used for. The Dagenham stone causeway has been associated with the movement of stock on the basis of (slightly ephemeral) poaching marks in the surface (Meddens 1996), but an end has never been found to any of these structures. The timber trackways are not robust enough for moving stock and are therefore presumed for people and built at a time when the marshes were getting increasingly wet; almost certainly a result of RSL rise and increased run-off arising from deforestation.

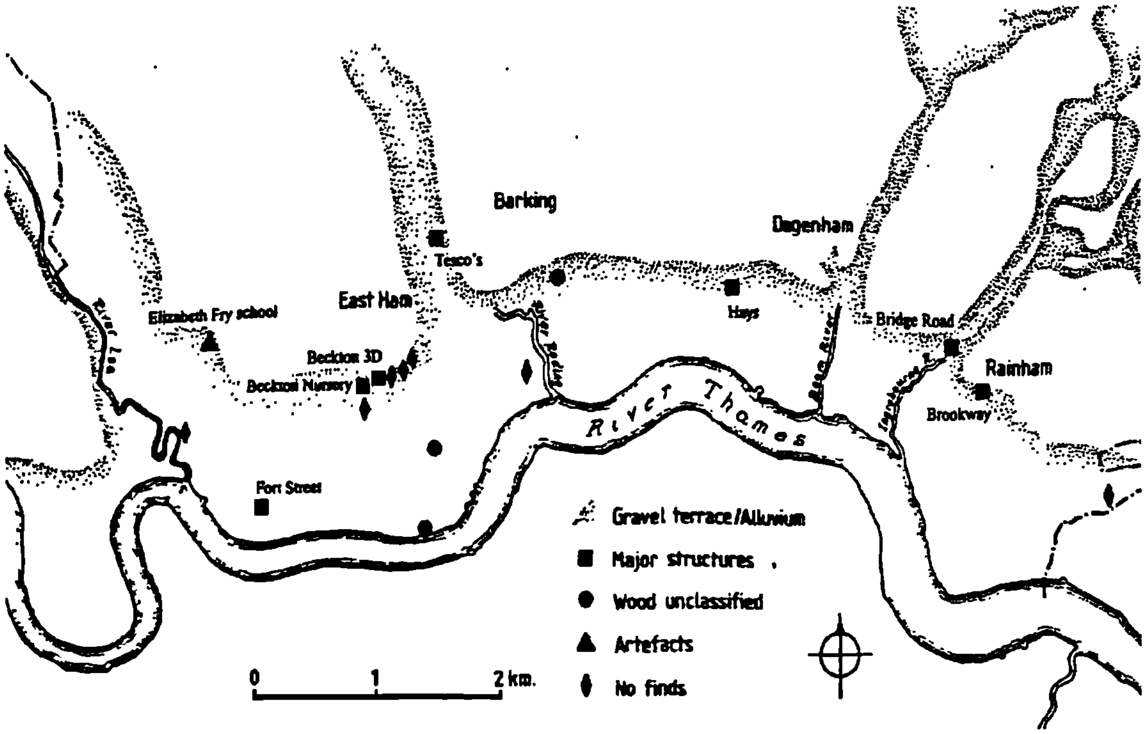
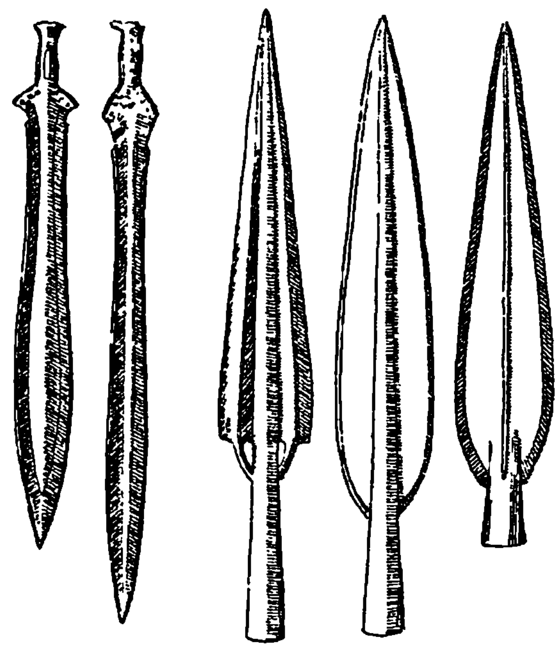



Figure 141. Map of the east London floodplain, from Meddens (1996)

In the absence of data, it is only possibly to speculate briefly. The trackways could have both a functional and ritual element to their use; functional in terms of moving people about the wetlands whilst procuring resources such as food and fuel, or taking a route down to the estuary, for water or transport. The structures are generally orientated north-south and so this latter suggestion has some merit. However, they could also have been used for ritual purposes, such as a manifestation of the perceived divisions and ways of progressing through the landscape (Whittle 1999). Furthermore this is a period of massively increased artefact (mainly weapons) and bone deposition into the Thames (Rowlands 1976; Barrett and Bradley 1980; Bradley and Gordon 1988). Although much of the metalwork and skulls were found upstream, there are still considerable numbers of finds from these downstream stretches, including the marshes. Also, objects such as the Dagenham idol have been found from this period. Furthermore, the area is likely to be underrepresented artefactually because of the massive dredging in the upstream but not the downstream stretches whilst limited peat extraction was undertaken.

A good comparison might be the excavation of the docks from where a considerable number of artefacts have been found (Blandford 1854; Spurrell 1889). The recent discovery (late May 2002) of a placed inverted Beaker adjacent to (an as yet undated) trackway in Beckton suggests ritual practices are associated with these structures. Indeed the entire use of Beakers in this area of London may have a ritual element, in that they only tend to be found on or adjacent to floodplain sites. The inversion may link to a wider cosmological association of inversion/opposition with parallel worlds, i.e. the world beyond death (Jon Cotton, pers. comm., Bradley 2000, 30).

It may be coincidental that this period of increased deposition of artefacts in the river co-incides with the turn from wetland to estuary expansion. The deposition of artefacts is almost certainly associated with agricultural intensification and the acquisition of wealth and consequently power (R. Thomas 1999; Merriman 2000), but the encroaching waters shrinking the available floodplain may played a part in votive deposition. Amongst all this there is still no evidence for Early Bronze Age activity, something not confined solely to London (Bradley 2001); nor is there evidence for widescale landscape clearance in the pollen records until the Middle Bronze Age in the downstream stretch of the inner estuary (Cotton 2000).



Rapier (second from left) is 0.6m in length. Spear heads – 0.4 to 0.3m in length

Figure 142. Bronze Age weaponry from the Thames, from Vulliamy (1930)

## 12.4 Second transgression

**Upstream (*c.* 100 BC- present)**

The information from Suffolk House (1 on Figure 143) indicates peat formation continuing until late in the Iron Age, however, the evidence from elsewhere in the central London floodplain shows that the transgression begins slightly earlier. Very little evidence demonstrates settlement even close to the area; the islands are not occupied and there are only a few clusters of artefacts, such as at Bermondsey Abbey (2 on Figure 143), but there are not *in situ*. Rather oddly, the City (3 on Figure 143) contains a range of Iron Age objects (Merriman 1987), but again there is no trace of settlement. Furthermore, much less metalwork is going into the Thames than in the mid-late Bronze Age. The quality increases, however, with objects such as the Battersea shield and Waterloo helmet (Merriman 1990). These objects may well be associated with burial rather than being the displays of wealth of the earlier period, particularly as there is very little evidence for the farming necessary to provide surpluses to buy bronze. An additional factor is the rise of iron; the ore was present locally and could be manufactured into tools much more easily than Bronze (Kristiansen 1994; Merriman 2000). This would have led to a decreasing need for bronze; without the necessity to trade overseas for bronze, people might have been drawn away from the Thames. These factors, in combination with the loss of field systems might be behind the apparent move out of the floodplain in conjunction with the formation of new tribal territories and a greater focus on defended settlements such as Queen Mary's Hospital, Carshalton (Adkins and Needham 1985; Bruce and Giorgi 1994, 4 on Figure 143) and Caesar's Camp, Wimbledon (Lowther 1945, 5 on Figure 143).

The incursion of Roman culture into London saw a re-occupation of the floodplain, from *c.* AD 47. Diatom evidence suggests that the river was more weakly tidal at this date than in the Late Bronze Age (Wilkinson 1998). The Mediterranean Roman people were unused to tides, as shown by the wrecked boats of Julius Caesar during the 55 BC invasion (Webster 1980, 37). This may have led to the construction of the first waterfront at such a high level (see above, Chapter 11). It is unnecessary to document the finds from this period, but rather to examine the Roman adaptation to the vicissitudes of the river. As has been shown, the Roman waterfront was constructed by a combination of apparently centralized government and *ad hoc* individual tenants. Nevertheless, the extension into the river indicates consistent adaptation to dropping relative river levels.

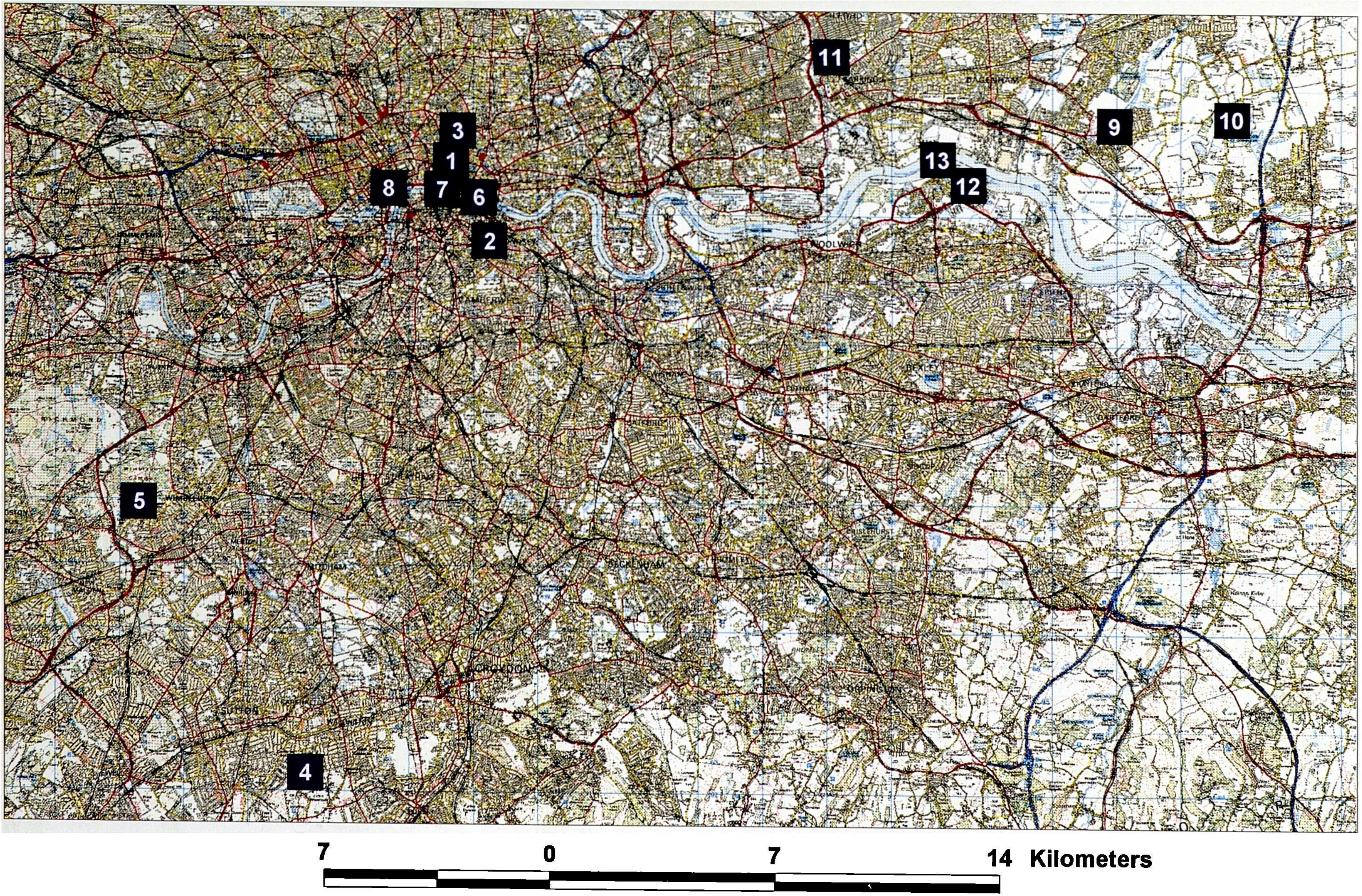



Figure 143. Map of sites mentioned in Chapter 12.4

| No. | Site | Eastings | Northings |
|---|---|---|---|
| 1 | Suffolk House | 3271 | 8077 |
| 2 | Bermondsey Abbey | 3340 | 7933 |
| 3 | The City | 3275 | 8125 |
| 4 | Queen Mary's Hospital | 2780 | 6248 |
| 5 | Caesar's Camp | 2240 | 7110 |
| 6 | Toppings Wharf | 3287 | 8036 |
| 7 | Winchester Palace | 3260 | 8041 |
| 8 | The Strand | 3053 | 8079 |
| 9 | South Hornchurch | 5325 | 8300 |
| 10 | Hunts Hill Farm | 5660 | 8310 |
| 11 | Uphall Camp | 4383 | 8508 |
| 12 | Summerton Way | 4800 | 8128 |
| 13 | Crossness | 4780 | 8150 |

Table 34. Sites shown in Figure 143

This indicates a desire to retain dominance over the land, because the effort and cost of periodically redesigning the waterfront and waterside structures would have been extremely high. This is, nevertheless, in keeping with the rigid 'Roman' mentality of building straight roads and walls, no matter how costly, inconvenient and easier it would have been to adapt to the obstacles rather than adapting them.

In Southwark, there is also evidence of this attitude. Rather than confining the settlement to the dry ground further to the south, a decision must have been made to utilize the marshy area directly south of the centre of the north bank settlement for the bridgehead. This led to the kind of embankments seen at Toppings Wharf (Sheldon 1974, 6 on Figure 143) and Winchester Palace (Yule 1989, 7 on Figure 143), indicating that the land would be made useable even if below highest river level. And yet the effort expended must have been greater than to build a slightly longer bridge. There is also evidence for reclamation to extend the settlement in addition to embanking. The Roman form of adaptation to the river is extremely labour intensive; it is adaptation of the land, rather than the people. Yet it is as a result of having placed their city in this location initially, and subsequently maintaining it in the face of declining water levels. The importance of the river for trading and transport must have significantly outweighed the disadvantages of the fluctuating position.

This contrasts very strongly with the Early Saxon peoples, who were obviously not drawn to the river but preferred locations generally far to the south of the Thames. It is only late in the Saxon and Saxo-Norman period when the strategic position of the river is valued, once more seen in relation to trade, particularly with the settlement at and above the Strand (Cowie and Whytehead 1989, 8 on Figure 143). This appears to be a period of stability in the rivers history, with no obvious change; by this time, the river is more strongly tidal than in the Roman period (Wilkinson 1998), but does not appear to be rising. This only changes with large constructions such as the caissons for the Colechurch London Bridge. From this date, tidal range is also subject to change as a result of construction.

## Downstream (c. 1500 BC- present)

The transgression in the downstream zone co-incides with another significant reduction in human activity. No more trackways (or other archaeology) have been found in the clays sealing the peat. There is limited evidence for the continuity of field systems on the terrace edge into the Late Bronze Age (Yates 2001), but the term 'Late' is generally taken to cover Middle and Late, and very little radiometric dating is available from these sites. Therefore these sites may go out of use when the transgression begins to bite. It certainly seems possible that if the marshes had previously been used for grazing that their submersion would have had a significant effect upon the local farmers who would have needed to relocate their livestock, or change their farming regimes. This is thought to have been a period when wealth was reflected in land possession and indeed in livestock (Yates 1999; Merriman 2000). Therefore, destruction of pasture would have had a detrimental effect upon the landholders and subsequently the political structure on which individual communities were based. Several new settlements are built on the northern terraces at this date, at South Hornchurch (Guttman and Last 2000) and Hunts Hill Farm (Greenwood 1997, 9 and 10 on Figure 143), and it seems possible that the descendants of the communities that built the trackways constructed and occupied these enclosures.

There is very little Early - Middle Iron Age archaeology in the downstream zone; this supports the suggestion that the area was generally de-populated in the Late Bronze Age with some limited evidence of continued occupation at Hunts Hill farm. Additionally, some elaborate metalwork was deposited in the river (Fitzpatrick 1984;

Champion 1994, 129). There is more evidence from the Late Iron Age, centred on Uphall Camp (Greenwood 1989, 2001, 11 on Figure 143), a univallate fortified enclosure above the floodplain but on the river Roding. At this date, London is thought to have lain at the junction of several territories, which might account for the sporadic activity and the apparent dissimilarity with southeast England generally (Merriman 2000). Furthermore, the river is thought to have acted as a barrier between these rival territories and as such, the floodplain was not an area in common use, perhaps literally analogous to a 'no-mans land'.

The situation did not change materially until the Roman period, and indeed the downstream stretch of the region was not settled substantially at all under the Roman occupation. Very little evidence has been recovered from the floodplain; Summerton Way (mentioned above, Chapter 11, 12 on Figure 143) being one of the exceptions (Lakin et al. 1999). In fact this is almost certainly an under-representation when compared with the records of Spurrell (1889) who found large amounts of Roman material at Crossness (13 on Figure 143). Some Roman ditching and boundaries have been found on the A13, presumably associated with fields, but nothing in the floodplain. There is even less Early Saxon material in this area; no villages have been found and practically no artefacts. Incidentally, this matches with the period of flooding and abandonment identified in the Somerset Levels, Romney Marsh (Rippon 2000, 138) and also the Belgian coastal plain (Ervynck et al. 1999). It is not until the medieval period that the marshlands are used for grazing and farms and manors spring up on the terrace edges. Reclamation is thought to have taken place from the early medieval period and the construction of river walls appears to have followed slightly later. However, the population density to land ratio appears to have been quite low and there would not have been the pressure on land that would require significant adaptation of the land to suit the gradually rising river levels.

## 12.5 Discussion

There appears to be changes in form and spatial patterning of human activity co-incidental with periods of floodplain change. It may never be possible to prove to what extent these are linked, nevertheless, it is important to at least examine the possibilities and put forward a model of change, no matter how bedeviled with the usual problems of bias, taphonomy and diagenesis.

### Patterns

There is limited activity occurring during the initial transgression. The type of mobile society present at the time was one that would typically leave few traces (Mithen 1999). Those traces, however, indicate that the Thames was of significance to them on two levels. Firstly, utilitarian activities such as tool manufacture and food procurement took place at the waters edge, both riverine and lacustrine. Secondly, ritual activity can be seen, with artefacts offered to the river. Mention has been made of belief structures associated with elemental forces, and the Thames does not appear to have been an exception to this. The activity recorded during the initial transgression is more prominent in the downstream estuarine reaches where a more dynamic riverside environment would have prevailed than in the upstream freshwater zone. By the end of the phase, the downstream zone shows evidence for technological developments in the form of expanding toolkits and acquisition of ceramic technology. It is not possible to state that the activity traces in the estuarine and freshwater zones were left by different groups, simply that the technology downstream seems to have been more advanced.

There is a hiatus of activity during the initial expansion of the wetlands, seen consistently across the study area. Where Early Neolithic material is present, it is found downstream at the end of the earlier transgression and perhaps can be tagged onto 'the Mesolithic'. The hiatus is substantial, perhaps lasting for two millennia. This is not to suggest that the Lower Thames was entirely devoid of people, but it certainly appears to be significantly less populated than before and there is no evidence for the 'agricultural revolution' of the Neolithic (Yates 2001). Unfortunately it is not easy to closely date Neolithic axes; many have been collected from the river and may well form a continuation of ritual offering in this period during the creation of the floodplain woodland, preserved still at Erith (Seel 2001). Thomas (J. 1999, 222) has argued that this was a period of monument building before the onset of sedentism and it is notable that London is very sparsely populated with monuments, which could account for the apparent lack of people at this date.

The hiatus persists into the second millennium BC and it ends at roughly the beginning of the transition from wetland development to estuarine expansion. At this date, trackways, field systems and settlements begin to appear in tandem with widescale deforestation and offerings of spectacular metalwork into the Thames. This persisted until the final submersion of the wetlands, approximately a millennium later when the estuary swallowed up the floodplain back to the terrace edge, approximately co-incident with the beginning of the Iron Age, *c.* 700 cal BC. Once again, there is a dramatic reduction of the amount of activity occurring both within and beside the floodplain, persisting until the Roman incursion. It is perhaps noteworthy that although within a period of major transgression, there appears to be a lowering of river levels during the Roman period. This reverses towards the end of the Roman period, subsequent to which, the floodplain appears to be abandoned once more for a further few hundred years until the importance of the river in trade is one more recognized.

From this (Table 35), it may be seen that there are significant changes in the pattern of human use of the floodplain and terrace edges which often co-incide approximately with the significant changes in estuary dynamics. The question is, therefore, to what extent are these linked?

| | Transgression | Wetland expansion | Second transgression |
|---|---|---|---|
| **Upstream** | Temporary camps, tool manufacture, food procurement, axes and adzes in the river. | Early absence, axes and bronze in the river, (arable) field systems, use of ceramics, burial, Vauxhall platform. | Elaborate metal in the river, city formation, embankment, reclamation. |
| Cultural processes | Mobility, seasonal sedentism, ritual. | Mobility, ritual, sedentism. | Ritual, rise of urbanism, investment in infrastructure. |
| **Downstream** | Permanent camps?, tool manufacture, food procurement, use of blades and ceramics, axes and adzes in the river. | Early absence, axes and bronze in the river, idol, trackways, inverted Beaker, settlements, grazing on the marsh. | Defended enclosures, field systems, small farmsteads and manors, reclamation, river walls. |
| Cultural processes | ? Sedentism, mobility, technological advance, ritual. | Mobility, ritual, sedentism. | Sedentism, farming, feudal systems, defence of people and land. |

Table 35. Summary of activity and associated cultural processes

## Culture or climate?

Literature on British prehistory is clear on the pitfalls of linking human activity with external/environmental forces, for example:

> *Archaeology has attempted to reduce material culture to an essence which must then be located within the realm of ideas or that of biological presences* (Thomas 1996, 18).

> *The relationship with place and with things is a social one in which the people belong to the land as much as the land belongs to the people. By turning the material world into a mere stock of resources, we sever ourselves from the possibility of this kind of dwelling* (Thomas 1996, 71).

This school of thought dates back to the writing of Gordon Childe (1950), who identified human culture as developing at a rate beyond simply maintaining equilibrium with environment. It is a constant issue with environmental archaeologists who seek to characterize interactions within human ecosystems only to be vilified for not identifying the root cause of all change at a cognitive level. Nevertheless, many archaeologists who endeavour to track human development in coastal or riverine systems tend to do invoking more processual-based approaches rather than using theoretical approaches such as phenomenology (Tilley 1994) or hermeneutics (Barrett 1994). There needs to be scope for archaeologists to examine the links between cultural and environmental change without having to base all change entirely on human cognitive dynamics to escape being branded an environmental determinist. This has been partially tackled by Brown (1997, chapter 9), who looked at the cultural reasons for inhabiting floodplains in light of the operational and cognized environment, positive and negative aspects and finally risk strategies. He further defines the problem of previous work being branded as deterministic on the basis of having used overly simplistic modeling (see Figure 144). In addition, floodplains are defined as providing:

*potential for the examination of past societies response to environmental change, at a variety of scales from the Bronze Age household on the Thames floodplain at Runnymede to the decline of civilizations .....unparalleled opportunities for truly integrated multidisciplinary studies of environmental change and human causes and impacts which may point to future threats and management solutions* (Brown 1997, 315).

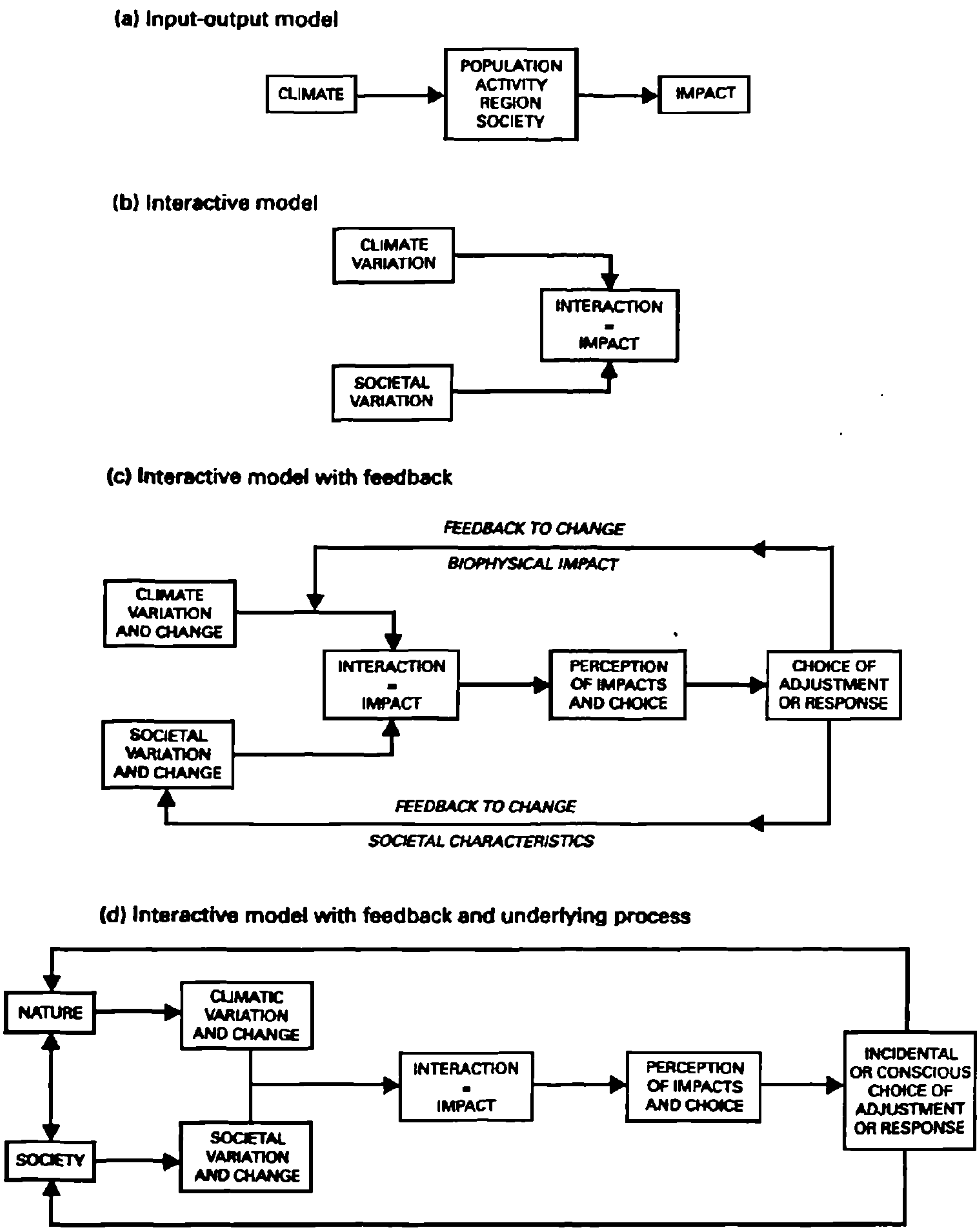



Figure 144. Models for interpreting human response to climate change, from Brown (1997)

In order to truly examine the sequence of change identified within the study area, the pattern needs to be examined from the standpoint of culture and possible co-incidence, in isolation from identified environmental change. The key issues are as follows:

1. There is more Mesolithic activity and a higher degree of technology present in the estuarine zone of the Thames, as opposed to the contemporary freshwater zone.
2. Ritual deposition of Late Mesolithic material into the river occurs, with a relatively high amount of artefacts when compared with the dryland zone.
3. There is no Early Neolithic presence during the period of wetland formation, only under the preceding period of estuarine expansion.
4. There is a very high incidence of Neolithic ritual deposition into the river involving imported artefacts.
5. Bronze Age activity occurs mainly when the estuary begins to expand against the wetland expansion. This generally takes the form of field systems and trackways.
6. Middle Bronze Age ritual deposition into the river is again exceptionally high (for England) with prestige goods imported from Europe.
7. There is an apparent swing of occupation centres between eastern London and western Essex during periods of wetland expansion and contraction to capitalize on available land.
8. There is practically no evidence for Iron Age occupation in the floodplain and terrace edges, other than Uphall Camp and isolated finds.
9. There is limited Iron Age ritual deposition into the river, but this tends to be of highly elaborate items.
10. The Roman city was sited in an unoccupied area in a period of apparent lowered river levels. The south bank had however, been quite densely used in the Bronze Age when the tidal head was migrating through the area.
11. Early Saxon settlement, although well known from Greater London is entirely away from the estuary.
12. It was only during the Saxo-Norman period that the floodplain was reoccupied.
13. From the Saxo-Norman period, urbanization occurred alongside the estuary margins initially, and only after the city had stretched to incorporate Westminster and down to the Tower, stretched back away from the Thames.

Possible cultural explanations of these points include:

1. Mesolithic activity is more likely to lie in the downstream zones of river valleys because they tend to be used as routeways (Mellars 1978) and it is only with the

rising sea levels and a shrinking valley system that Mesolithic people are gradually driven upstream.

2. Mesolithic offerings in rivers are not unknown and are likely to be linked to worship of elemental deities. Nevertheless, the amount in the Thames is unusual on a national level (Lewis 2000a).
3. The very limited Early Neolithic material in the floodplain could be associated with this as a period of monument building (J. Thomas 1999, 222), which occurred outside Greater London. The material at Erith and Rainham could be classed as Mesolithic/Neolithic transition prior to the concept of monumentality. The locational bias towards the estuarine zone would relate to point 1 with there having previously been a strong link with the outer estuary.
4. Neolithic offerings to watery places are reasonably common, and although there are relatively large numbers from the Thames, this is as likely to derive from complex cultural systems rather than supplication to the river itself.
5. The fluorescence of activity just before renewed estuarine expansion may simply be co-incidental with the widescale fundamental change in subsistence that occurred at this time in southern England, with the creation of extensive lowland field systems (Yates 2001, Bradley 2001). Admittedly, the reason behind the timing of this event is not understood. Nevertheless, the appearance of large tracts of grazing marsh will have made this an attractive area in which to practice a pastoral economy. Furthermore, the importance of run-off into the floodplain following deforestation should not be underestimated.
6. The abandonment of the (submerging) floodplain in the Late Bronze Age may be associated with the construction of ring-forts and the associated change in social systems. Nevertheless, it is difficult to view this removal from the heavily used floodplain as entirely separated from the environmental causes leading to its submersion.
7. The balance in occupation between western Essex and east London could be associated with territoriality of groups. However, this has previously been explained (Cotton 2000) as arising initially through increased land availability when the wetlands expanded in Essex. This then led to the relative increase of later Neolithic activity in Essex and the subsequent relative increase of Middle Bronze Age activity in east London as the population chased usable land, followed

by a re-population of western Essex in the Late Bronze/Early Iron Age. It is hard to find a convincing cultural explanation for this pattern.

8. The realignment of land and occupation using natural barriers to divide tribal land in the Iron Age of southern England is a well known if poorly understood phenomenon. This would account for the abandonment of the area, if not necessarily explaining it. However, a reason that is often put forward for the withdrawal of people from this area and similar ones is of climatic deterioration and overexploitation of marginal farming land (Caseldine 1990; Macklin et al. 1992; Pryor 1996; Merriman 2000).
9. The relative decline in deposition of objects into the river during the Iron Age is surely linked with the withdrawal of people from the area. Nevertheless, the sheer value of the items ending up in the Thames (see Figure 145) indicates that it maintained an important role in ritual practices.
10. There are many theories for the positioning of the Roman city, ranging from the similarity of the hilled north bank to the seven hills of Rome, the lack of previous occupants and the position of the tidal head. It seems likely that the river and valley side determined the choice of location, given the theory that the Thames was used as a barrier between rival Late Iron Age territories (Merriman 2000). Locating the Roman city there was prudent, in terms of not being directly on the territory or Oppida of a conquered tribe and also with good transport access.
11. The position of the Early Saxon settlements is likely to have been determined entirely culturally with a rejection of urban dwelling and an emphasis on smaller farming communities.
12. The re-occupation of the area is based on a change to a trading community with the *emporium* of Lundenwic and one that needed the river in order to develop and maintain overseas trading links.
13. Urbanization is obviously a cultural phenomenon, but the initial expansion along both riverbanks rather than to the north and south indicates the centrality of the river, presumably for transport and trade.

*c.* 0.95m in height

Figure 145. The Iron Age Battersea shield, from Merriman (1990)

This brief summary of the key developments indicates that they have come about as a result of both cultural and environmental causes. Some of the timing suggests a positive response to environmental change, particularly the presence of Mesolithic/Neolithic transitional material in the estuarine zone, the abandonment of the floodplain at the mid/Late Bronze Age transition, only shortly after the development of large-scale field systems and the balance of occupation between east London and Essex. The continuation of activity on the terraces behind the floodplain (i.e. South Hornchurch) shows that it was only the floodplain that was abandoned and not the region, which strengthens the argument for environmental causes determining relocation.

It is noticeable that the periods of relatively large and unusual amounts of offerings in the river co-incide with the periods when the estuary is expanding, i.e. the Late Mesolithic and mid-Late Bronze Age. The question of ritual offerings is very difficult to deal with, as it is impossible to gauge the reasons for such deposits; it is possible that in these cases it is simply co-incidence. Nevertheless, the position of the mid Bronze Age Vauxhall structure at roughly the tidal head would argue for a link between RSL rise and increased deposition into the Thames over and above the displays of wealth needed to maintain positions of authority within a hierarchical society. The most comparable estuary, the Severn (see below) does have some offerings from these periods, but on a much smaller scale.

It seems apparent that throughout later prehistory, the river has remained constantly important for transport, maintaining social systems, ritual ceremonies and basic life-sustaining activity. The fact that there is still some activity associated with the river even in periods of apparent wide-scale abandonment, such as parts of the Neolithic, Early Bronze and Iron Age shows that it has maintained a position of importance in the collective minds of the inhabitants of the valley above that of a simple waterbody for moving boats and watering stock. It seems possible that the importance of the eyots as being 'ritually charged' places (Brown 1997, 288; Cotton 2000) has a role to play in this.

From the Roman period this changes; the river is still afforded a central place in Roman life, but the ritual element is lessened, perhaps associated with the introduction of the Roman pantheon, more allied to anthropomorphized virtues rather than a more elementally-based belief system. This is also likely for the pagan Saxon population, where trade also plays a relatively insignificant role in life. Since the Late Saxon period the river has played a central role in the development of the city and it is only with the decline of the port in the early 20th century that this ceased to be the case.

## Comparisons

Tendency of sea level movement in the Thames has been examined in Chapter 11 and proved to be typical of other estuaries in southern England. It is important to examine the archaeological sequences in these other systems in order to see whether there is evidence elsewhere for human response to environmental change. The Severn is the best comparison, in terms of length of occupation, although there is no specific urban centre. Romney Marsh and Southampton Water do not have significant amounts of archaeology and so it is more difficult to consider the relationship between cultural and environmental change. Although the Fenland sequence did not match the Thames, it is still a populated area in the key periods under question, i.e. later prehistory and consequently, is worth briefly examining.

### *The Severn*

The Severn estuary has a tradition of antiquarian finds similar to that of the Thames, with early records of buried forests, stray finds, axes, boats and skulls from dock digging and exposed tidal flats (Bell 2000b, 3). Late Mesolithic activity is also present in the Severn estuary, at Goldcliff (Bell, Allen et al. 2000); otherwise, excavated Mesolithic sites are scarce, with the exception of a series of footprints found in the estuary, the site at Westwood Ho! (Balaam et al. 1987) and a series of finds from Pembrokeshire (M. Lewis 1992). However, Early Mesolithic material is not generally found within the floodplain or valley sides, so the part of the sequence represented in the inner Thames estuary by the B&Q and Waterloo sites is not well represented in the Severn. It seems likely that this phase of occupation could well be offshore or has not yet been found at depth away from the intertidal zone.

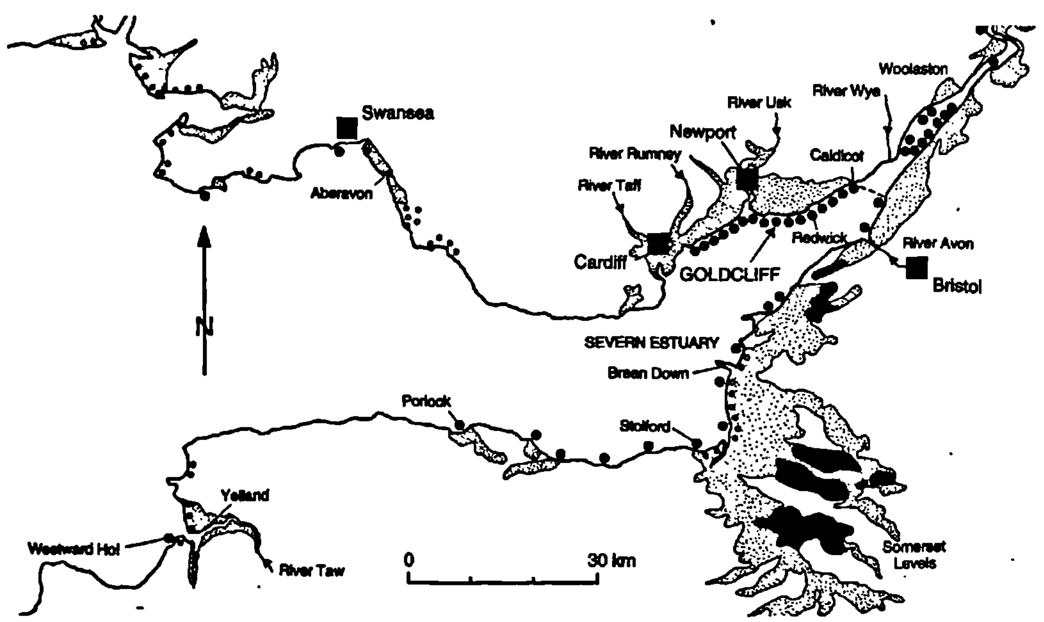



Figure 146. Location map of Goldcliff, from Bell, Caseldine et al. (2000)

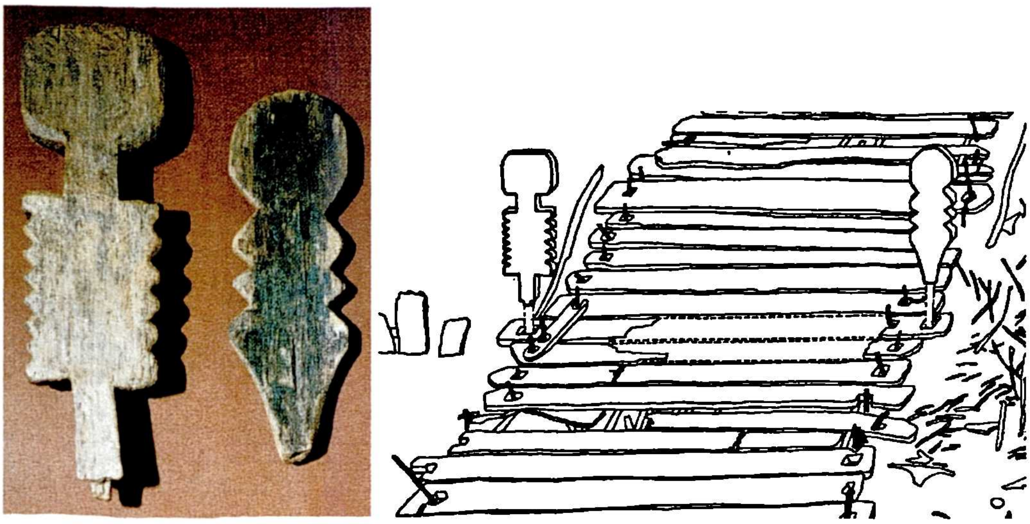
The Goldcliff Mesolithic site exhibits similarities to the Erith complex in that Late Mesolithic material is present on a (semi-) terrestrial surface with substantial flint scatters and subsequently activity during the transition from estuarine sedimentation to peat formation, which has left a preserved forest in both cases. Excavation and preservation is better at Goldcliff, but the sites are directly comparable although Goldcliff is situated relatively further out in the estuary. The suggestion that neither site was a home base but were short-lived lithic manufacture sites for tools to be made and then used elsewhere is interesting and may indicate a wider practice amongst river-based Mesolithic groups. A point of difference is that there is some evidence for use of the salt marsh at Goldcliff, whereas Erith is not occupied again until the mid Bronze Age.

A very noticeable parallel between the Thames and the Severn comes with the Neolithic archaeology in that there is relatively little of it in both estuaries, but particularly so in the Severn. The Thames has its valley-side sites such as Rainham and others along the terrace edge and the large amounts of axes and maceheads that have been dredged. Nevertheless, there is still relatively little evidence for settlement. The Severn has a number of finds collected from the intertidal zone, some material from the interface of the charcoal horizon and peat at Goldcliff and evidence for human activity in the pollen spectra away from the intertidal zone. It is likely that the amount of dredging in the Thames has significantly biased the record by over-emphasizing the amount of axes here in relation to less-dredged rivers, so it may be that the Severn comes quite close to the pattern of deposition in the Thames. The lack of evidence in the Thames has been ascribed to several possible causes; building monuments elsewhere, avoidance of the wooded peats and possible relocation to Essex. Similar arguments could be extended to the area of the Severn. The Mesolithic communities could have been building monuments in Wales and avoiding the marshes. 'Essex' could equate to 'further out in the estuary' but there is no evidence for occupation here either.

160mm in height

Figure 147. Somerset god-dolly, from Coles and Coles (1986)

What there is, however, is substantial evidence from the Somerset Levels (Coles and Coles 1986), where Neolithic trackways such as the Sweet and Bell Tracks demonstrate that these areas were being used, possibly following inundation of previously occupied areas such as the Goldcliff complex. There are several parallels between the Neolithic Thames wetlands and the Somerset levels. Perhaps the most obvious comes with the Fort Street trackway and the many trackways in Somerset, but also the carved figurines of the Dagenham idol and the Somerset god-dolly. Although the context of the Dagenham idol is not well known, it is suggestive that many of the European wooden idols have been associated with trackways, which include the Somerset god-dolly and the Iron Age Wittemoor 'couple' from Lower Saxony (van der Sanden and Capelle 2000).



Large figure =1.05m, small figure = 0.9m in height

Figure 148. Wittemoor 'couple' and conjectural reconstruction of their position on the trackway, from van der Sanden and Capelle (2000)

A further similarity between the archaeology in the Severn and Thames lies in the occurrence of a number of human skulls. Deposition of these in the Thames has been discussed above. A number of skulls have been found in the Severn (Bell, Richards et al. 2000), during archaeological excavation and commercial development in the area. They have a wider date range than those from the Thames, which are mostly Bronze Age, and there are also many less in the Severn, nevertheless, it is another indication that similar practices are occurring in both rivers, the prehistoric finds likely to be associated with excarnation and offering skulls to the river. Associated weapons are rare in the Severn, but the rapier from Avonmouth strengthens the case for similarities in Bronze Age ritual practices. The skulls from the Severn are interpreted as part of a wider ritual landscape (Bell, Richards et al. 2000), inspired by the river itself; a suggestion made above for the practices associated with the Thames.

Another parallel comes with the Bronze Age. Both areas have practically no Early Bronze Age material, but have much larger mid Bronze Age assemblages. This is one of the richest periods, archaeologically, in the Thames, with settlement, field systems, and trackways in the marshes and the metalwork in the river. Some metal work has been recovered in the Severn, i.e. spearheads at Rumney and a palstave near Redwick (Neuman et al. 2000). A series of mid-Bronze Age buildings have also been found at Rumney, Redwick and Collister Pill. This type of evidence is not present in the Thames, but on a broader level, it can be said that there is domestic activity of this date, and significantly more than present before in both estuaries.

It is with the Iron Age that a major difference lies; the inner Thames has practically no Iron Age activity in the estuary at all. Conversely, it is in this period that the site Goldcliff was occupied once again. A great many timber structures have been found here, in the form of a series of huts and trackways crossing the peats and mud flats (Bell 2000c). Cultural reasons are considered to be behind the move of people away from the Thames, however, these pressures, thought to be associated with the need for defence were apparently not in play in the Severn. Potentially the political climate was more stable here, or indeed the topographic conditions made for natural defence. In general, however, it can be said that the patterns of archaeological occupation in the two estuaries are similar, as is the sequence of environmental change. The two are not necessarily linked, however, the relative disuse of the wetlands in the Neolithic through to the mid-Bronze Age is striking, as is the ritual use of the rivers in the Bronze Age. The lack of urban centre on the Severn in the Roman and later historic period makes comparison beyond the Iron Age difficult.

### *Wootton-Quarr*

Research on the coastal margins of the Isle of Wight, at Wootton Quarr has found a great deal of intertidal archaecology (Loader et al. 1997), which can be viewed in tandem with the evidence for RSL change from Southampton Water (Long et al. 2000). Similar to the Severn and the Thames, a Neolithic buried forest is present here, but subsequently submerged as RSL rose. This is dated earlier than in the Thames, around 3000 cal BC. Another variation from the pattern observed in the Thames and the Severn is the amount of Early Neolithic activity, including the setting of fish traps along the coast and the construction of trackways, again buried during the Neolithic under estuarine sediment. As yet, there is no firm evidence for ritual activity, which is prevalent in the Thames and perhaps indicates a more river-orientated belief system within the society using the Thames Valley than that using the Wootton-Quarr coast

### *Fenlands*

Anthropogenic impact on the environment has been picked up in pollen spectra from the Fenland which shows some similarity with the Thames data. There is very little evidence for Mesolithic activity, with limited clearance around a known site at Peacocks Farm (Waller 1994a, 105). Unusually, there is evidence for Early Neolithic cultivation from Haddenham in the form of clearance and increase of, particularly, *Plantago lanceolata*. This is in sharp contrast with the general trend of little Early Neolithic domestic activity in the estuaries, or even generally. However, this sort of information is largely absent from the later Neolithic and Early Bronze Age, which fits better with the pattern seen in the Thames and elsewhere in southern England (Bradley 2001). This indicates that there may have been a very short-lived phase of arable farming (such as suggested at Woolwich Manor Way in the Thames) mixed with pastoral grazing (Clark and Godwin 1962; Pryor et al. 1985). This, as with the Thames appears to have been succeeded by a withdrawal from the area towards a more mobile, monument-orientated culture away from the fen edge (Whittle 1978), who created structures such as the Southwick, Haddenham and Etton causewayed enclosures (Palmer 1976; Hodder 1981/2; Pryor 1998). In this sense, there are many similarities between people moving out of the Fens and the Thames estuary into new and striking monumental landscapes away from the wetland environment.

Following the abandonment of the monumental landscape, some similarities can be seen, with the adoption of fen-edge field systems in the Early Bronze Age. Although this is earlier than in the Thames Valley, it is their abandonment that more closely parallels the Thames. Both systems appear to be flooded at the end of the Bronze Age (Pryor 1980) and there is very little evidence for activity in the fens or at the fen-edge at the Bronze Age/Iron Age transition (Pryor et al. 1985) but unlike the Thames, there is a substantial Iron Age presence.

A key aspect of the archaeology of the Fenlands comes with the ritual landscape of the Late Bronze Age centred on Fengate and Flag Fen (Pryor 1996, 2001). This area has been mentioned several times and does not need reiteration, other than to stress the similarities of ritual deposition of weapons from liminal wetland/dryland zones into the waterbodies of Thames and the Fens at a time when both environments appear to have been coming out of a period of wetland growth into a marine transgression proper.

### *Dutch coast*

There is scope for limited comparison with the prehistory of the Dutch delta (Louwe Kooijmans 1980) in terms of type of human occupation. The Mesolithic period is entirely similar with a patter of migration within the river systems. The Mesolithic/Neolithic transition seen within the Thames estuarine zone is also matched in the Netherlands with some mobility and the introduction of ceramics. Subsequent to this, there is a hiatus in the floodplain that may correspond with the monument building period seen in the Thames. The Early Bronze Age in the delta is a period of settled farming, something not seen in the Lower Thames, or indeed in much of Britain at all (Brück 1999b), but the later Bronze Age phase with use of drier land for settlement and wetter land for pasture does match extremely well. He identifies several key criteria for successful occupation; limited 'inconvenience' from water and economic viability of land, whether for permanent or seasonal occupation (Louwe Kooijmans 1980, 112). He further identifies the reasons for change in occupation patterns as primarily a response to RSL change. Generally the change in the prehistoric period was either to abandon or attempt to defend land, but generally abandonment in the end.

More evidence comes from Voorne-Putten, close to the Rotterdam coast (van Ginkel 2001). The area has been gradually reclaimed from the sea and has been almost continuously occupied, however, as apparently the case in the Thames, the Mesolithic communities of this area (who made the Willemstad manikin) were gradually forced up the estuary here onto higher ground because of rising RSL. There has also been recovery of evidence for the development of Mesolithic/Neolithic transitional culture at Vlaardingen and Hekelingen (van Ginkel 2001). As with the Thames, from *c.* 4000 cal BC, wetlands communities developed, in this case owing to barrier protection. The wetlands were heavily utilized until a further period of marine transgression (Dunkirk 1a) remodeled the area, from *c.* 800 cal BC, roughly contemporary with activity in the Thames. Unlike the Thames, but similar to the Severn, Iron Age communities established themselves on high land, built farms and practiced a pastoral economy.

## Summary

There is some evidence within the study area for active human response to patterns of RSL and environmental change. This takes the form of changing centres of occupation within the floodplain and also potentially some of the ritual deposition of objects into the river. The positioning and subsequent repetitive rebuilding of the Roman waterfront is also seen as actual responses to RSL continue to use the river. There are other key developments that are almost certainly entirely culturally based, i.e. the lack of Iron Age and Early Neolithic activity. There is difficulty around the deposition of offerings into the river. A number of explanations have been put forward, associated with self-aggrandizement and displays of personal wealth, but it is also possible that some of the objects were made as offerings to changing elemental forces.

The archaeology of the Thames estuary shows a continually evolving human presence, engaged in the same forms of technological and cultural development seen widely across southern England. Response to environmental change manifests itself in transmigration along, across and finally off the floodplain, with shifts in settlement focus between the London and Essex stretches of the river relating to land availability. The river appears to have been the focus of ritual activity throughout the prehistoric, particularly during transgressive episodes. It is only with the appearance of Roman culture and religious beliefs that this ceases.

Comparison, particularly with the Severn estuary and the Fenland indicates that the Holocene activity in the Thames is consistent in many ways with activity in similar environments in southern Britain. This should not be surprising, but the wetland archaeology of the Thames estuary has been relatively poorly studied - the fens have benefited from the presence of the nearby Cambridge University and a department of Archaeology with a strong research interest in local archaeology. This has led to a tradition of fieldwork in the region for many decades. Co-incidentally, the same department has also had a strong research interest in the Somerset levels, where the pioneering work of John Coles (Coles and Hibbert 1968) established the area as a pre-eminent location for English wetland studies, which extended into the Severn estuary. Both these areas have benefited from large-scale wetland surveys, funded by English Heritage (Olivier and Coles 2001). Sadly, London has not had a university department with an interest in its archaeology. Furthermore, the archaeological tradition in London, strong though it is, is based on the urban rescue archaeology of the 1970's. There is a very long gap between the pioneering work of men such as Spurrell, Blandford and even Pepys who recorded wetland archaeology as it appeared, and the records of the post-PPG16 generation of archaeologists. Nevertheless, the style is similar, with observations made from small areas being developed that occur by chance. The Thames estuary needs a systematic approach to its archaeology before it can truly be comparable with its better recorded parallels in the Severn and the Fens.

# Section IV: Conclusions

## *Chapter 13. Conclusions, Evaluation and the Future*

## 13.1 Conclusions

### Summary

This thesis has examined the evidence for RSL change in the inner Thames estuary over the Holocene period whilst also considering the impact of such change upon the human population. Several issues have been raised that may be of interest to researchers in the future.

RSL analysis, using through tendency and age-altitude indicators has demonstrated that the inner Thames estuary has been subject to gradually rising sea level throughout the Holocene. A widespread phase of wetland expansion in the Neolithic and Early Bronze Age co-incided with a slow down in the rate of rise, but is considered to have occurred against a background of rising RSL. Examination of archaeological riverside structures indicates a drop in MTL during the Roman period, of *c.* 1.5m. This shows a reversal by the end of the Roman period continuing up to the period of artificial embanking and reclamation, which is considered to show the beginning of anthropogenic modification of tidal range, with the construction of the Colechurch London Bridge in 1081.

Examination of spatial patterning of archaeological evidence has shown that there are changes in lifestyle, which appear to be a result of response to environmental change. This is difficult to identify and harder to quantify, however, it seems that the human population adapted to fluctuating land availability by moving upstream ahead of rising waters, by using the greatest areas of expanding marsh and finally by moving off the infilling floodplain altogether.

Various methodological aspects have assumed an importance in this work. Palaeotidal range has been shown to be potentially more influential than compaction, possibly inducing errors in the order of several metres. This may put calculations of indicative meaning, sample compaction, leveling error etc., into greater perspective. The validity of using archaeological datasets to try and resolve past tidal range has been demonstrated. Even tide gauge records for the last hundred years will be important because RSL has risen significantly in this period (i.e. c. 1.5m at London Bridge, www.environment-agency.gov.uk/subjects/flood/149357/). This measurement is substantially more than the various error calculations attributed by Shennan (1986a; 1994) and others, for instance (Jardine 1986) in their calculations of MSL. The problem of using modern tidal ranges for past MSL calculations will only be exacerbated in future as RSL continues to rise. It could be argued that calculating past tidal range is more important than producing more RSL graphs. This has a wider relevance than for scholarly advancement; RSL data has a value to society with reference to flood defence. This is an increasingly important part of life and indeed government spending (www.defra.gov.uk/environ/fcd/; www.environment-agency.gov/subjects/flood/211195) in order to protect life and property as Britain becomes more subject to coastal erosion and flooding.

Miscalculation in academic study, although important, is not generally life threatening. Currently, data generated through sea level research is being used to directly influence calculations used for river defence in the Thames. Errors in the order of several metres could have very substantial implications. For instance, the housing estates in Thamesmead, where the Voyagers Quay and Gallions Reach sites may be found, is currently four metres below MTL and protected by hard defences, but is downstream of the Thames Barrier. Consequently, it is highly vulnerable to increasing river levels and high magnitude-low frequency flood events. An underestimation of future river levels will have serious impacts in such marginal areas. Although planning guidance (PPG25) is now in place to attempt to restrict housing development in floodplains, (www.planning.dtlr.gov.uk/riappg25/) it is unlikely that this will have much effect in areas where pressure on land for redevelopment is high.

## 13.2 Evaluation of aims and objectives

The original aims of this study were:

1. To establish the record of relative sea level driven riverine and estuarine changes in the inner Thames estuary during the Holocene
2. To examine developing patterns of archaeological settlement in proximity to the Thames
3. To explore the links between data gathered during study of relative sea level change and archaeology in the Thames floodplain

The first of these aims was identified as the central point of this thesis. Through conventional sea level analysis, it has been shown that RSL has risen almost uninterrupted throughout the Holocene. This was initially relatively rapid with widespread waterlogging on the Devensian gravels beginning from 7500 cal BC. This initial transgression was followed by a reduction in the rate of RSL rise, with a concomitant wetland expansion, from *c.* 4000 to 1500 cal BC. This was followed by a second major transgression that has continued almost uninterrupted until the present day, with an apparent drop in RSL during the period *c.* AD 50-300 shown in the archaeological record and through the reconstruction of palaeotidal range.

The examination of archaeological activity within the geographical and temporal limits of this study has shown that there is a relationship between environmental change and human settlement within the floodplain. This is bound up with cultural processes, nevertheless, it has been shown that settlement patterns shift to make best use of available land, whether by moving downstream during the major regression, or by moving upstream during transgressions to have some land to occupy. The centrality of the river to religious beliefs seems clear, in conjunction with the use of the river to "consume" offerings as displays of wealth. Even with the rise of urbanism, the importance of the Thames is manifest in the manner the city spreads along rather than away from it.

Aim 3 is concerned with the use and examination of two very difference methods for reconstructing changes in the relative levels of the Thames and its floodplain. This key outcome from this aim is that new light has been thrown on the issues of tidal range; a subject that is contentious but often glossed over. The examination of the results obtained through this research has shown significant problems with the established methodology and suggestions have been made for how to rectify them using archaeological data. It would appear that problems of using modern tidal range can outweigh issues of compaction.

The original objectives were:

1. To revise the current sea level curves for the Thames (Devoy 1979; Long 1995; Sidell et al. 2000, 110).
2. To establish a pattern of Holocene sedimentation in the middle Thames estuary.
3. To evaluate the geographical and archaeological methodologies used in the construction of sea level index points.
4. To evaluate the use of palaeotidal data in the calculation of relative sea level.
5. To examine the influence of the human population on tidal range in the Thames.
6. To examine methods of reconstructing sea level changes in the historic period.
7. To examine the links between spatial patterning and chronological distribution of archaeological sites within the Thames floodplain.
8. To examine the validity of undertaking doctoral research using material collected within the context of developer-funded archaeology.

Objective 1 has been undertaken through conventional RSL analysis, and the results can be seen in Chapter 11. The new data confirm the trends shown by Long (1995), and Sidell et al (2000) but are at variance with the curves of Devoy (1979) in that no drop in sea level is postulated for the period *c.* 4000-1000 cal BC.

Objective 2 relates to stratigraphy within the estuary. It is clear that the overall stratigraphy is complex and local factors preclude the possibility of establishing a high-resolution model of sedimentation within the floodplain. Nevertheless, there are consistent trends which can be seen across the study area and are reflected in the stratigraphy recorded elsewhere, including, to some degree, the Devoy model (with the exception of the typesite at Tilbury itself). These trends show a period of Early Holocene to Late Mesolithic/Early Neolithic mineral accumulation, with estuarine clay silts forming in the later stages of this. Subsequently, wood peats form throughout the study area, replaced by alder carr and then salt marsh from the mid to the Late Bronze Age and exceptionally, the Late Iron Age. This is replaced by a further phase of estuarine mineral sedimentation, in most places only replaced by urban make-up, which can dates from the Roman period onwards, depending on location. In some areas, such as Wennington, urban development has yet to occur.

Objective 3 refers to overall methodology and it is now clear that archaeologists and geographers can take aspects of methodology from each discipline in order to improve the overall resolution of RSL calculations in environments where archaeological deposits are present.

Objective 4 has been the focus of discussion in Chapter 11. It remains clear that there is great need for modelling of palaeotidal levels, in that the data shown in this thesis indicates almost a trebling in tidal range in the Thames over the last 2000 years. Calculation of MSL using modern and "Roman" tide levels has shown a difference of up to 5m and this underlines the importance of palaeotidal reconstruction.

Objective 5 is not discussed in great detail. It appears clear that there was no anthropogenic influence on tidal range during the Roman and Saxon period whist no revetting or embanking has been identified for the pre-Roman period along the Thames at all. The construction of the Colechurch London Bridge seems to have been the first example of anthropogenic impact on tidal range, with a weir-effect created on the upstream side. It is subsequent to this that embanking and reclamation on both sides of the Thames constricted the river sufficiently to increase tidal range.

Objective 6 has been addressed through the discussion in Chapter 11. It is clear that there are still many difficulties to be overcome. The use of waterfront structures as proxy data for establishing HAT, MHWST, MHWNT and MLWNT is based on logical inference and is considered a robust method, within limited error margins. These relate to the exactitude of the structures construction at HAT. However, what is less well known is the limit of the estuary, particularly in the earlier part of the historic period. Therefore, this method requires a more rigorous approach to ecological reconstruction and indeed more work. From the earth sciences, it is clear that only few people have been able to address RSL change over the last 2000 years, for instance (Edwards 2000; Gehrels et al. 1996; Van de Plassche 1999). The main problems come with access to suitable sediment, which cannot easily be overcome, and dating difficulties, which can be resolved. Problems with dating are largely blamed on the difficulty of dating what is generally minerogenic sediment (Edwards 2001), however, this is a poor argument as techniques such as OSL and $^{210}$Pb can be used in such situations (for example, see Cundy and Croudace 1996).

Objective 7 is of key interest to archaeologists working in the floodplain, and is discussed in Chapter 12, where it is demonstrated that there are apparently real links between environmental change and human activity, indicating an adaptive strategy to changes in floodplain configuration. In the prehistoric period this is exemplified as straightforward relocation to the areas of most suitable land whilst the Roman period indicates attempted subjugation of natural forces to the needs of the urban population. Throughout the Holocene, with the exception of the Early Saxon period, the river forms a key aspect of life in this part of the Thames. The apparent disregard the pagan Saxon population showed for the river is fascinating, but not readily explicable.

Objective 8 was included for a variety of reasons, not least of which was to examine the justification for undertaking the work in the manner it has been undertaken. There are good reasons for undertaking doctoral research within the context of developer funded archaeology, such as availability of data and also, perhaps surprisingly, funding. Nevertheless, there are certain drawbacks, which have been made manifest through this work, most particularly relating to time-management and curation of material. Finding time to undertake the research is extremely difficult, as in a commercial situation, there is rarely time for research and it therefore requires an iron will to make time available. With reference to curation of samples, in the unit and museum environment, the ideal situation is to consign material to an archive store or a bin as quickly as possible, once analyzed. Unfortunately, the duration (and perception thereof) required to analyze material varies from person to person, which can lead to the precipitate removal of samples. However, experience has shown that loss of material can also happen in University departments, so this should not be considered a substantial reason for not undertaking doctoral research from within a commercial unit. The scenario is indeed likely to become more common as pressure on grants and the cost of living rise, in combination with the increasing need to undertake a doctorate to progress a career in archaeology or indeed most academic disciplines. This is likely to lead more students to undertake research part-time whilst supporting themselves.

The key drawback of using data from developer-funded work is of location. These sites occur because people wish to develop the land, not because of burning archaeological issues. This was not considered to be a problem for this thesis because several years elapsed from first conceiving the idea and then starting the work, which allowed selection from a wide range of sites, partly because London is the most heavily developed area in Britain. However, this would be a significant problem in less developed areas and where time was more pressing. Nevertheless, it should be possible to add to the corpus of sites by judicious fieldwork if permission can be obtained.

There are some advantages to undertaking research in this manner, generally associated with money and other resources. Access to facilities such as archives and SMR's may be easier than from an academic department; money for radiocarbon dates can be obtained on the back of conventional projects whilst a further advantage comes from being within a work environment with a peer group devoted to a closely allied aspects of the subject matter, in this case, archaeologists investigating the development of London. This can balance up the intellectual benefits of working within an academic department where the research interests are many and varied.

### Strengths and weaknesses

These need to be considered to gauge the success of aspects of the work. There are a number of specific weaknesses, some of which have accrued through undertaking part time research from a developer funded archaeological background, but these have been outlined above. Examining the quality of the dataset is one aspect that must be considered. Taphonomy is one of the larger problems and makes comparison with Devoy, for instance, difficult, particularly the identification of the *Taxus* forest. This is now well known along the stretch of the Thames, from both recent (i.e. Seel 2001) and antiquarian (i.e. Spurrell 1889) sources. Yet Devoy does not record it and it is impossible to know is this is a real absence or not. It seems unlikely, but difficult to prove. A further issue of comparison comes with nomenclature. Devoy, although occasionally noting the presence of gytjja, does not include such deposits on his diagrams (1979). Yet, these are important sedimentary facies that can be used to show finer detail of depositional environment than that which may be obtained through simple subdivision into minerogenic or biogenic. This makes direct comparison with the new lithological dataset difficult.

A further significant weakness of this work is the shortage of palaeotidal modelling, which requires a detailed understanding of topography. It is unlikely this can ever be undertaken in the inner Thames because of the amount of change there has been, through historical and recent modifications such as land reclamation and dredging.

In terms of strengths, several become apparent when this work is compared with either archaeological or geographical works examining sea level change. Archaeological research does not generally take a rigorous scientific approach to RSL reconstruction and that must be seen as a weakness of approach. Furthermore, this research has drawn upon a larger dataset than generally used for local/regional sea level analysis, both in terms of sequences examined and sites available for comparison. In addition, the use of 49 new radiocarbon and three dendro dates (admittedly not all of which could be used as index points) is unusual and when combined with the extant database of sea level index points for the Thames, must make the Thames one of the better served estuaries in England.

A further strength lies in the temporal and spatial coverage of this thesis. It has been mentioned above that the historic period is difficult to examine. Through the use of archaeological date, this has been undertaken to an extent. Furthermore, several sequences with Late Devensian organic sedimentation have been incorporated, previously unavailable information in the Thames. Spatially, this is the first time the inner Thames estuary has been examined in detail, and when combined with the work of Devoy, now provides an estuary-wide model of RSL change.

## 13.3 Future directions

There are a series of issues that have been highlighted within this thesis as key points requiring further research. These may be subdivided between archaeology and geography and are presented here as bullet points. This is because the issues have been discussed above in the text, or are generic to the discipline and do not need expansion.

### Geography

These issues may be divided into those relating solely to the Thames estuary and more generic issues, which although by no means new, are nevertheless of fundamental importance:

#### *Thames estuary*

- Establish why Tilbury appears to deviate from the general trends shown elsewhere
- Research the poorly known periods such as the Early Holocene and the Saxon period
- Map and examine the ecological development of the *Taxus* forest
- Create detailed palaeogeographic maps for the Thames to facilitate palaeotidal modelling
- Establish the reasons for the apparent drop in MSL during the Roman period

#### *Generic*

- Research methods of resolving compaction issues associated with archaic sediment.
- Undertake palaeotidal modelling to use in the construction of index points.
- Develop the use of historic tide data.

## Archaeology

### *Thames estuary*

- Expand the area of coverage away from the City.
- Establish the tidal range for the prehistoric period throughout the estuary.
- Track the movement of estuarine waters throughout the Holocene, specifically for crucial periods such as the Bronze Age and Roman period.

### *Generic*

- Enhance methods of using stratigraphy to measure RSL change.
- Disseminate the use of archaeological methods and data to a wider audience.
- Become more rigorous in the approach to sea level reconstruction.
- Undertake cross-disciplinary projects on sea level change.

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